

Railway Mechanical Engineer

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Railway Mechanical Engineer

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Men and institutions in or related to railroad work have been on trial during the past year as they have probably never been on trial before in the history of railway transportation. As one

Mechanical Associations on the Defensive

of the results of the world war there has been created a general state of mind which not only is exceedingly critical of all existing institutions but which is even inclined to assume that the burden of proof lies with those who would defend them. Technical associations of railway officers and supervisors, particularly in the mechanical department, have not escaped this situation, and developments during the past year have added tremendous force to this questioning of values and of the right to continued existence.

Most of these associations have become closely affiliated with organizations of supply companies whose interests in the various fields of association work have led them to place their products on exhibit during the annual conventions. These exhibits have undoubtedly been of great mutual benefit. The unprecedented conditions in the railway market for the past two years, however, have been such that the assembling of these exhibits did not seem justified this year. Following the decisions to that effect, there immediately began a movement among the railroad associations to postpone their conventions, which culminated in the resolution passed by the Association of Railway Executives recommending the general adoption of that policy by all organizations within its control. This action has raised several questions on the answer to which the future of these associations may depend.

First, if these organizations are of any value to the railroads in developing a deeper interest in better railroading and in improving practices, why was not their work most needed by the roads in the present period of stress? The

abandonment of this work at such a time certainly implies a lack of confidence in their value, by their members as well as by the railway executives.

Second, are exhibits of tools and equipment and the support of the exhibiting organizations the prime object of these conventions? Recent events, taken at their face value, suggest an affirmative answer to this question.

Third, if the answer to the second question is "Yes," are the railroads justified in encouraging the continuance of these conventions, even after a return of prosperity? There is no escape from the conclusion that the roads ultimately must bear the expense of these exhibits, as well as part of the expense of the conventions themselves.

The *Railway Mechanical Engineer* believes that the work of these associations should be continued. But if it is to be continued the purpose and the return expected should be clearly formulated in the minds, both of the association members and of the executives who direct the policy of the railroads. There were sufficient exceptions to the general rule of conduct this year to prove that a successful convention could be held even under the present unfavorable conditions. The International Railway Fuel Association convention was well attended and the work done fully justifies the course taken by the executive committee. Furthermore, its success was not in spite of, but partially because of railroad support. The Traveling Engineers' Association, in a half-hearted attempt to evade responsibility, held a meeting the nature of the work at which would have fully justified the executive committee had it called a full-fledged convention. The influence of the latter would have been felt with much greater force than was possible with the small attendance which the call for the meeting brought out.

The responsibility for the success of these associations lies

primarily with the membership. Unless the members are thoroughly convinced of the value of their organization and are willing to back that conviction by their actions, how can they expect to win, even half-hearted support from railway managements? The time is ripe for some clear thinking on this subject by railway association members. This should result in well defined conclusions. When those conclusions have been arrived at they should be backed up with all the concerted force of which the membership is capable.

Limited numbers of machine tools have been purchased by the railroads in the past few weeks, and it is reasonable to suppose that, in view of the need for modern shop equipment and the gradual improvement in the financial situation, still more orders for machinery will be placed in the near future. It is not amiss at this time, therefore, to consider several suggestions on the purchase of machine tool equipment, suggestions demonstrated by experience to be of prime importance, not only to the railroads but to the manufacturers as well.

The false economy of purchasing on a price basis only has been pointed out many times in the *Railway Mechanical Engineer* and most railroad men realize that such a policy can well be characterized as "penny wise and pound foolish." Mechanical department men responsible for shop output are in a position to know, if anyone does, just what machines are needed, and if the financial condition of a road does not warrant the purchase of the specific machines requested, it would be better to postpone buying rather than get cheaper substitutes which do not fill the need.

Another undesirable practice, followed perhaps unavoidably on some roads, is the buying of a large order of machine tools at one time, and not ordering again for two or three years. It would be much better wherever possible to replace each machine as it becomes too worn, or out of date, for economical use, and no difficulty will be found in financing these replacements provided adequate depreciation accounts are maintained. These are two main arguments in favor of replacing machinery as it becomes worn out and thus incidentally distributing orders throughout the year. From the point of view of railroad men the sooner obsolete machines are replaced the sooner is efficient shop operation secured. From the manufacturer's viewpoint, the distribution of orders throughout the year will enable him to employ a medium force of men in a shop of medium capacity all the year round. The result will be a reduced cost to the manufacturer who can sell machines for less money while making the same profit.

A third practice to be recommended in the purchase of machine tools is to hold up requests for bids until there is at least a reasonably good prospect of immediate purchase. In a certain case, bids were asked for 18 months before the order was placed and in an endeavor to close the order a representative of the manufacturer made a trip to the shop immediately. Several subsequent trips were made in the 18 months and eventually all profit from the sale went to pay for the salesman's time and traveling expenses. It is obvious that if this practice were followed extensively, the manufacturer would soon be compelled to charge more for machines to offset the additional selling cost. But the objection may be raised that it is often necessary to ask for prices and data far ahead of possible orders so as to determine the advisability of installing certain machines. This difficulty can be readily overcome by stating on the request that the bids are required for purposes of preliminary estimate only.

It may not be entirely clear why railroad men should care if machine tool manufacturers are put to unnecessary expense,

and the answer is that whatever represents an economic loss to one branch of industry is harmful to the entire country. The position of the United States as the leading industrial nation is due in no small measure to the enterprise, foresight and persistent effort of manufacturers who design and build time and labor saving machinery. For their mutual advantage, railroad men should co-operate in every possible way with machine tool manufacturers so that the latter will be able to furnish machinery at the lowest cost consistent with good material, careful workmanship and a reasonable profit.

It is an unfortunate fact that the word "cost" conveys various meanings to different people. A failure to recognize its full significance has been the cause of much fruitless discussion, has resulted in many a false decision and has brought failure to multitudes of promising enterprises. Through many hard knocks

and in accordance with the law of the survival of the fittest, the successful manufacturer or merchant has learned that the cost of an enterprise includes far more than the expenditures for labor and materials. In the years which are now little more than a tradition, the shrewd manager was often able to carry on a business successfully for a long time without a full knowledge of the various factors which made up his manufacturing costs. His business sense led him to recognize their existence in a general way and thanks in a large measure to the lack of severe competition, he was able to add a sufficient amount to his direct costs to ensure a profit after meeting all incidental obligations. If he guessed too low in one case, his next guess may have been sufficiently high to offset the loss. If he failed frequently to make a sufficient allowance for overhead, the result was bankruptcy and the courts distributed what was left among the creditors.

The natural evolution was the development of an accurate cost accounting system which would not only take care of and properly distribute the burden for indirect labor, power, lights, general materials and supplies, but also such obscured, though nevertheless vital, factors as insurance, taxes, maintenance, depreciation, betterments, replacements, procuring of capital, sales expenses, provision for periods of low production, losses, unforeseen contingencies, etc. The development during the last 20 years of industrial cost accounting methods is one of the striking features in connection with our large manufacturing organizations. Accounting has been developed to a high degree. As a result managers now base their decisions in regard to provision of manufacturing facilities, what shall be made, the character and quality of the product and even the entire selling campaign upon the bed rock of accurate cost accounts.

When we turn from the manufacturing to the railroad field, the contrast in cost accounting is a startling one. As the function of a railroad is to provide transportation and the maintenance of its rolling stock is only one of many incidental activities, shops have been looked upon frequently as a necessary evil and maintenance expenses have been met when and because they could not be avoided. In addition, the character of railroad accounts has been shaped to meet the requirements of the Interstate Commerce Commission reports. A railroad does not sell the product of its shops in an open market in competition with other shops. Even experienced and successful railroad managers have not learned to appreciate the importance and bearing of many of the factors affecting shop costs. They have not been forced to do so as have industrial managers and have too often closed their eyes to the problem which is recognized to be a complicated one. There were also many easy ways to disguise a number of the factors and allow them to be absorbed in various general accounts.

An unusual combination of conditions recently has led a

number of roads to place orders with outside builders for the repairs of locomotives and cars. As orders for new equipment were lacking, builders have been glad to accept such contracts and thus keep their plants in operation. Other roads are considering taking similar action. The question naturally and always asked at such a time is "How will the cost for work done in the contract shop compare with the cost for the same work done in our own shops?" This is a question which is easy to ask but difficult to answer. Certain figures in connection with the cost of work done in railroad shops may be available, but when they are analyzed they are found to be exceedingly incomplete and lacking in many elements. Railroads have not accumulated records which are of much value or aid in making a decision in such a case.

Realizing the importance of a more complete knowledge, one of the large railroads recently called in a corps of trained accountants to obtain the cost of rebuilding 50 box cars in their own well-equipped shops and the cost of similar repairs to an equal number of the same kind of cars in a contract shop. Every effort was made to select cars which were in a similar condition and the local railroad officers co-operated heartily in the effort to secure full information. The results of this investigation are given in an article appearing in this issue. The difficulties experienced in obtaining some of the necessary information, the factors considered and their bearing on the total costs are most enlightening and bring out distinctly many things which are too frequently overlooked, but cannot be ignored if cold facts are desired instead of a mixture of facts, guesses and omissions.

The lot of the foremen and local supervisory officers in the mechanical department is often difficult and trying. They are confronted every day with petty troubles that are nevertheless serious in their effects. The labor problem, which to the higher officer is a question to be settled on broad general principles, presents itself to the local officer more as a personal problem involving men with whom he is closely associated. Delays and engine failures and the occasional derailments and wrecks are vexatious to the higher officer when he sees them on the morning report, but they are only an incident in the affairs of the day. For the man down the line they mean hours and sometimes days of continuous exertion that taxes his patience and his physical endurance. To the conscientious foreman the position calls for the best efforts he can put forth, and though the responsibility may be limited to a small plant the problems are often just as difficult as those of the man higher up. Anyone who is familiar with the situation can understand why the problem of getting and keeping the right kind of foreman is one of the most serious the roads are facing.

The first step needed to place foremanship on a better basis is a recognition by the management of the true position of the local officer. Too often the foreman is not taken into the confidence of the management. He is not made to feel that he can look to the higher officer for whole-hearted co-operation in solving his problem and often he is not properly supported in doing constructive work. Personal contact with other foremen and with his superiors, while not discouraged, is seldom encouraged. The head of the department is usually busy and finds little time to cultivate a personal acquaintance with the men. Probably he does not intend to keep aloof from the local officers, but if his actions give that impression, the effect is much the same. The foreman's most direct contact with his superior is likely to come when things have gone wrong. He may get an incorrect impression from a letter written in a critical tone after some unavoidable failure. It is hard to keep up courage when the best effort meets with criticism. The natural reaction is to seek to avoid

censure and to concentrate attention on minor details; to do the work in a thorough but mediocre way, working to get by, without ambition, without inspiration.

The desire to avoid censure is strong in every normal man, but a feeling that is quite as general and in an ambitious man even stronger is the desire for approbation. If only a man's mistakes are noted, his chief aim will be to avoid such mistakes. On the other hand, if his constructive work is recognized, he will try to do more constructive things. Almost every railroad office has someone on the alert to mete out criticism for each mistake, but how many letters of commendation are ordinarily written to the man down the line? Would it not help matters if the foreman, vexed and discouraged with his many difficulties, could be made to feel occasionally either by an interview or by a cheerful letter that the management realized his position and appreciated whatever constructive work he had done?

There are a number of signs which point to the possibility for soon effecting a much needed improvement in freight car conditions. For the month of August

A Brighter Outlook for Car Repairs

reports from some 200 Class I railroads show a net operating income of approximately \$90,000,000, the largest for any month since August, 1919.

This was an increase from approximately \$69,000,000 for the same roads for the previous month, which in turn was the largest net income for any month since October, 1920, the last month of good returns before the heavy decline in traffic set in. It is true that this result has been obtained by drastic curtailments of maintenance expenditures. But if previous experience is any criterion, the prospects are good for a continuing increase in the volume of traffic through September and October before the normal seasonal decline in traffic movement may be expected to set in. Such, in fact, has been the case during September. That this showing has actually justified some increase in the volume of car maintenance is evident from the fact that the first decrease in the number of bad order cars for the year was shown by the report of the Car Service Division for the first half of August.

Since there is a considerable reserve of idle motive power tied up in good order it seems probably that the heaviest increases in maintenance of equipment expenditures may be expected in the car department. With approximately 16 per cent of the freight cars of railroad ownership out of order, three-quarters of which are in need of heavy repairs, such increases in car repair work as take place should be devoted to heavy repairs. On much of the equipment now in bad order this class of repairs has been deferred for years—in many cases probably since before Railroad Administration control. Undoubtedly many of these cars in need of heavy repairs could successfully be returned to service by a continuation of the patch work practice which has so long been in effect. Continually deferring the needed heavy repairs, however, constantly adds to the volume of light repair work without decreasing the heavy repairs which ultimately must be taken care of. The inevitable result is an increase in the average cost of maintenance which the roads can ill afford to continue. Throughout the period during which the number of bad orders has been increasing there has been little increase in the number of light repairs, indicating that this class of work has been taken care of currently even under the present scale of curtailed expenditures. Any increase in expenditures made possible by the steadily improving financial situation should be devoted to a permanent improvement of freight car conditions.

A FIRE in the car shops of the Missouri, Kansas & Texas at Wichita Falls, Texas, on September 20, damaged the woodwork mill, several freight cars, a crude oil tank and the entire machine shop equipment—estimated loss, \$75,000; cause, unknown.

COMMUNICATIONS

Insulation of Freight and Passenger Cars

NEW YORK.

TO THE EDITOR:

I have read with much interest the discussion in your issue of September, 1921, by Arthur J. Wood, and I am glad indeed that my article as published in your July, 1921, issue has at least caused comment and criticism.

The subject is beyond doubt one which should receive the attention of all railway engineers, due to the varied interpretations that have been placed on the efficiencies of insulating materials, and while Mr. Wood's criticism is helpful, yet it is not conclusive, as he does not offer in a concrete form some real definite plan which may or may not be accepted by engineers as being finally correct.

I mentioned the fact in the opening paragraphs of my article that there existed great differences of opinion on this subject of insulation, dating back to the time of Jean Claude Peclet, nearly a century ago. We have had quite a number of investigations carried on in the various laboratories since that time, and during the past few years we have also had some very able papers presented before the various engineering societies as well as investigations by the following:

U. S. Bureau of Standards: A. C. Willard and L. C. Litchy; H. C. Dickinson and M. D. Van Dusen, University of Illinois Engineering Experiment Station; Prof. Charles Ladd Norton, Massachusetts Institute of Technology; L. B. McMillan, University of Illinois; Charles H. Herter, paper read before A. S. M. E.; R. L. Shipman, paper before Third International Congress of Refrigeration, 1913; J. A. Moyer, Pennsylvania State College; Arthur J. Wood and E. F. Grundhofer, Pennsylvania State College, and many others that could be mentioned.

The basis of most of our investigations have, however, been built up on the results obtained by the eminent French physicist Peclet and investigations by Rietschel and Grashof.

The principal difficulty seems to lie in the varied types of apparatus used in the experiments and which naturally give different results. In time we will no doubt have to arrive at a satisfactory method acceptable to the engineering field.

The methods most commonly employed in this country may be classified according to principle at least as follows:

1. Ice Box Method.
2. Oil Box Method.
3. Cold Air Box Method.
4. Hot Air Box Method.
5. Flat or Hot Plate Method.

The following is an excerpt from Bulletin No. 102 issued by the University of Illinois:

"The most prominent American investigator has been Prof. C. L. Norton of the Massachusetts Institute of Technology. The best equipped thermal-transmission testing plant in this country has been erected by the Armstrong Cork Company, at Beaver Falls, Pa. A similar plant is located at the Pennsylvania State College at State College, Pa. In the tests run at the former plant little attention has been given to surface temperatures, since only actual or overall transmission air to air coefficients were desired. In the plant at Pennsylvania State College both air and surface temperatures are measured by means of platinum resistance pyrometers, and the Engineering Experiment Station at State College has been studying the effect produced on the heat transmission by varying the relative humidity and velocity of the air passing over the outside surface of a building wall.

"The Worcester Polytechnic Institute has recently con-

ducted a series of tests on the heat transmission of various types of ice house construction. Prof. J. R. Allen, University of Michigan, has recently reported the results of tests on transmission coefficients for glass made under a variety of conditions."

There has been very little data published on the subject of "car insulation" and the writer is perfectly satisfied that after the subject is further investigated there will be some recommendations that would be of considerable value.

In my discussion on this subject I have taken what I consider the nucleus of all the latest experiments and brought together the salient points regarding methods for arriving at transmission factors.

The matter of air space in the walls of passenger and freight cars probably cannot be counted on for much value, and in many cases might just as well be omitted, as there are practically no instances where such an air space will remain a dead air space for an indefinite period of time. Therefore, the question of air space is debatable. However, the writer has given the benefit of a certain value in his article and which is according to good practice at the present time. Undoubtedly the best and most dependable results will be obtained by dividing up air spaces and inserting layers of insulation which more nearly approaches the so-called "dead air space."

Mr. Wood is correct in his reference to Table III to the effect that the values of C and K are transposed as this table was reproduced from tests made by the U. S. Bureau of Standards and the error has been handed down, but in the discussion the value of one was used for average conditions.

So far as surface resistance is concerned, and in view of the uncertainty of same, the value as used; namely, $\frac{1}{K}$ or 0.5

was used as the total for inside and outside surfaces combined, this representing good practice based on recent tests.

The writer quite agrees with Mr. Wood that there is a need of more extended scientific investigations to assist in a better design of insulated walls, and this would be an excellent subject for the American Railway Association to take up and establish a definite method for testing the value of insulations such as are used in car construction. This would then establish a standard basis to be used, and eliminate or reduce to a minimum the varied methods now employed.

The Pennsylvania State College has contributed some exceptionally good information on this subject of heat transmission and with the excellent laboratory equipment we should no doubt learn much through their very able studies. Arthur J. Wood and E. F. Grundhofer have recently presented a very valuable paper on this subject.

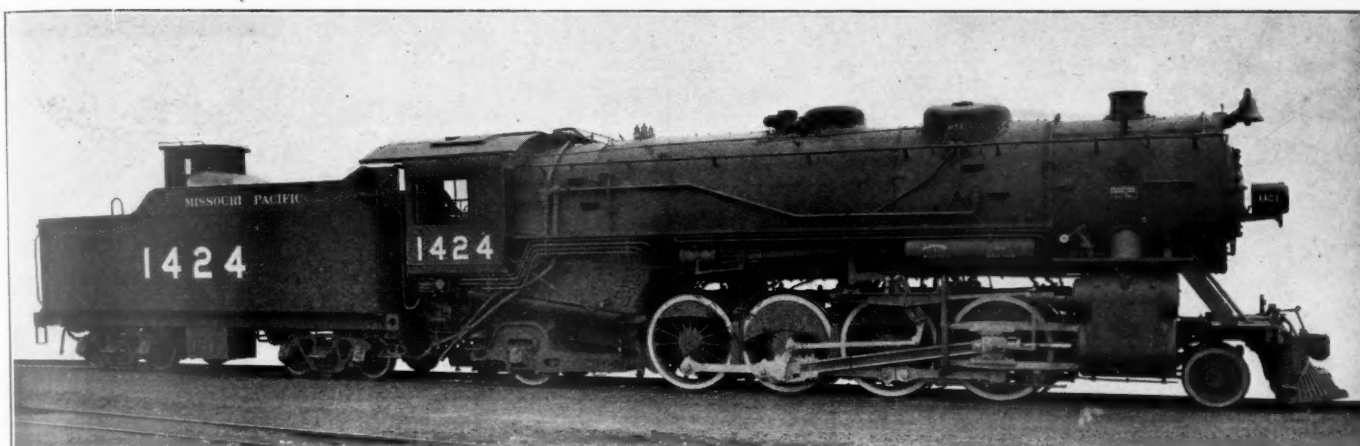
The writer is not prepared to offer any particular criticism as regards the values obtained by the Standard Car Committee in the Union Pacific tests, but merely reproduced the figures purely for a comparative basis.

The conductivity value of 6.576 used for the insulation in the formulas is correct for the hair insulation as this figure is borne out by later tests, and by referring to Table II it will be found that for Keystone Hair Felt the conductivity value given is 6.5, which checks very closely with the value of Salamander insulation, used as the basis for calculation.

The object of my discussion was to bring to the attention of railway engineers a suggested method of procedure for their guidance in arriving at the heat transmission of car walls without laying too much stress on values of conductivity, as these values would have to be selected from some accepted authority.

The subject is a deep one and quite complicated and I know of none in the engineering field upon which there is such a variance in opinions, but eventually we will no doubt arrive at a satisfactory solution.

WM. N. ALLMAN.



Mikado Type Locomotive Equipped with Booster

New Locomotives for the Missouri Pacific

Harter Circulating Plates Applied to Improve Boiler Capacity—Booster Increases Tonnage 13 Per Cent

THE Missouri Pacific has recently added to their equipment 50 locomotives built by the American Locomotive Company. This includes 15 six-wheel switchers (0-6-0 type), 25 Mikado (2-8-2 type), 5 Pacific (4-6-2 type) and 5 Mountain (4-8-2 type) locomotives, none of which types are new on this road. The six-wheel switchers are of the same design as those received about a year ago; the Pacific type engines are practically a duplicate of those previously built, while the Mikado and Mountain types are of entirely new designs.

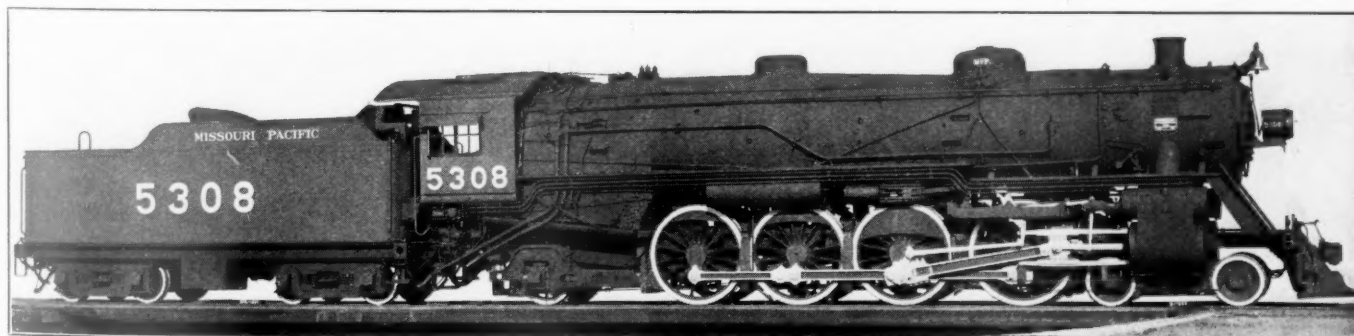
Mikado Type

The Mikado locomotives previously used were of the government light, or U.S.R.A. 2-8-2-A type allocated to the road during the war. These engines are of 54,600 lb. tractive

application, convenience in maintenance and reduction of fire hazards.

The boilers of the Mikado type as well as the other locomotives are equipped with Harter circulating plates which it is estimated have added 10 per cent to their capacity. This device consists essentially of a horizontal plate slightly below the center line extending entirely across the boiler from a point just behind the feedwater inlet to within about six inches of the back tube sheet. Outlets for steam are provided by pipes placed at intervals on either side which lead to the steam space at the top of the boiler barrel. The general arrangement is shown in the drawing of the boiler for the Mountain type locomotives.

On the Mikado locomotives the boiler horsepower is 93.9 per cent of the cylinder horsepower without allowance for



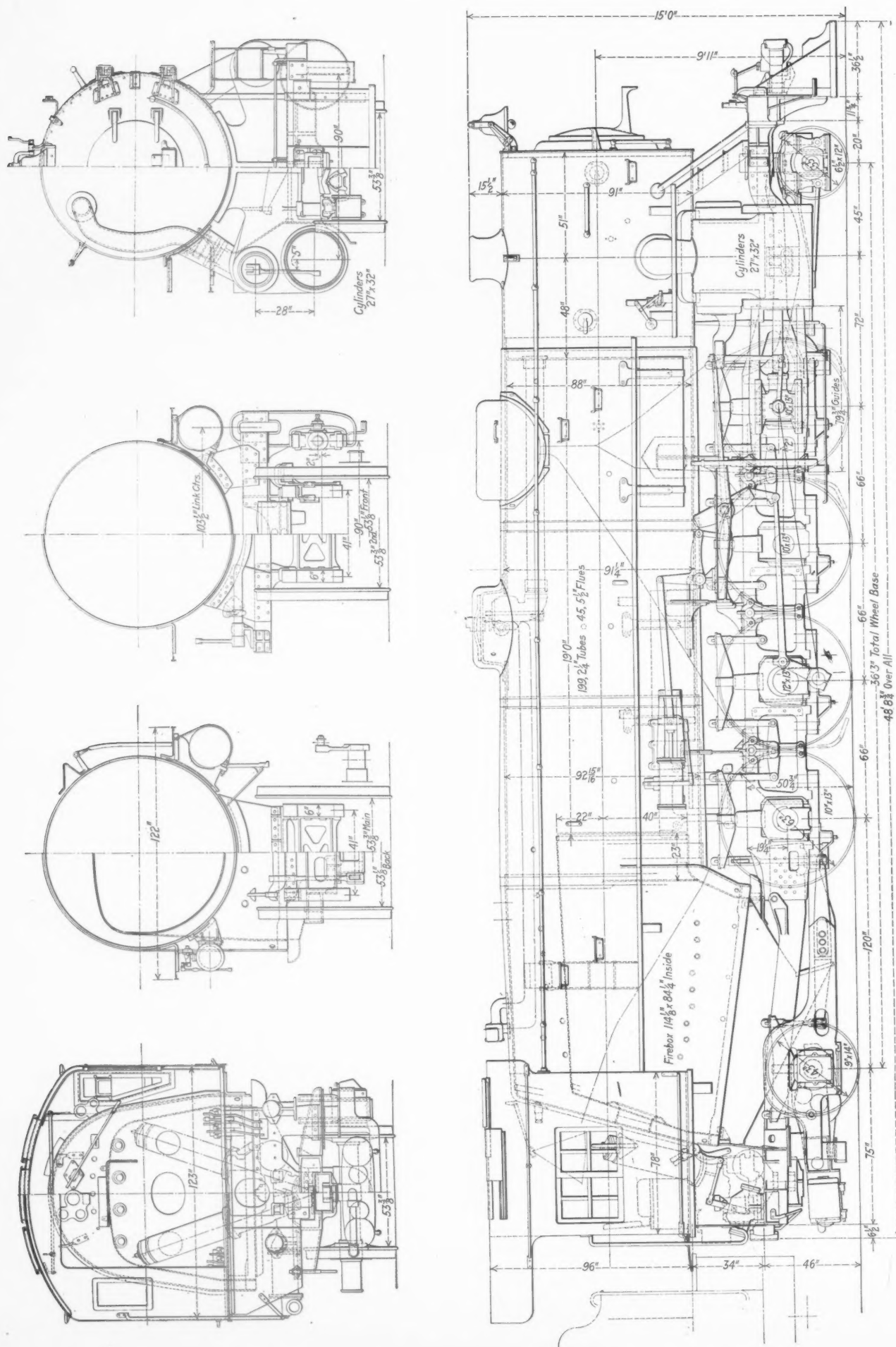
An Efficient Mountain Type Locomotive of Medium Weight

effort, have 26 in. by 30 in. cylinders, the total weight being 290,800 lb., with 221,500 lb. on drivers and 63 in. wheels. The new locomotives have 10 per cent greater tractive effort and an equivalent increase in weight and are handling 10 per cent greater tonnage. Among the special features are floating bushings for the middle connection bearings which are giving much better satisfaction on engines of this size than the stationary bushings previously used; Alco reverse gear; Duplex type D stokers; Franklin grate shakers and adjustable driving box wedges; Chicago flange lubricators and Jemco unit spark arresters which are said to be an improvement over the master mechanics' design in ease of

the circulating plate and on the Mountain type, the rated boiler power is even less. All of the engines have, however, proved to be free steamers in service.

Delta trailing trucks, equalized with the drivers and equipped with brakes, are used on all road engines. Of the 25 Mikado engines, two are equipped with boosters and provision is made for their future application to the other engines. In actual service it has been found that the locomotives equipped with boosters can handle 13½ per cent more tonnage than the same design of engines without the booster.

The booster increases the tractive effort 9,000 lb. and



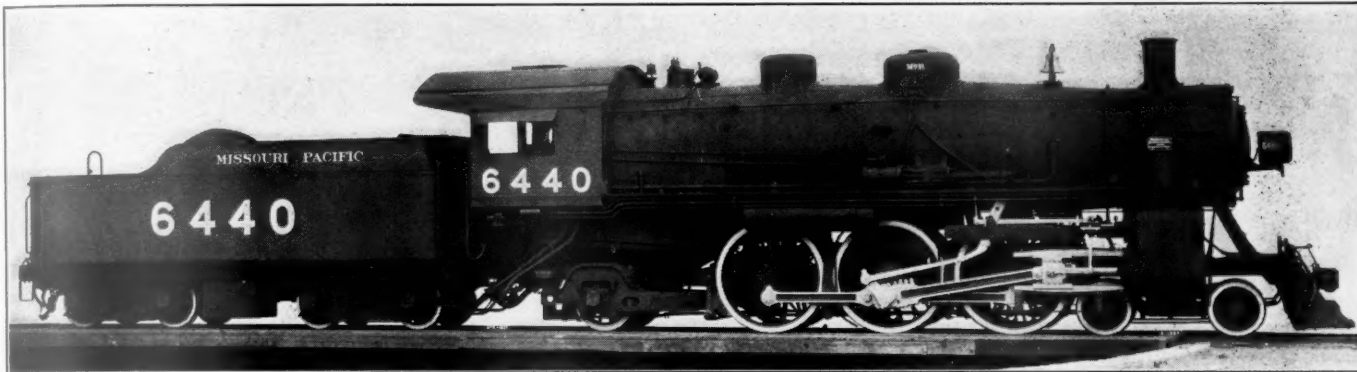
Elevation and Sections of New Mikado Type Locomotives for the Missouri Pacific

adds 3,500 lb. more weight on the trailing truck, 4,500 lb. more on the drivers and 1,000 lb. less on the front truck.

The ruling grade on the line where the boosters are used is five miles long so that the demand on the boiler for steam to supply the booster as well as the locomotive cylinders is severe and prolonged and any lack of capacity would be developed quickly. In actual tests the locomotives have handled a full tonnage over the ruling grade at a speed of approximately 10 m.p.h. With the reverse lever in the corner,

69 in. wheels. The new locomotives were designed for the same service and to correct some of the troubles which have been experienced with the older ones. In attempting to make pronounced changes in the design, an interesting problem was encountered owing to the fact that the condition of bridges and structures on the section of the road where the engines were to be used necessitated limiting the weight on the drivers to 226,000 lb.

The size of the driving wheels was increased to 73 in. to



Pacific Type Locomotive of 40,000 lb. Tractive Effort

the throttle wide open and the injector on, full boiler pressure was maintained.

Mountain Type

The Missouri Pacific has been using for some time a number of U.S.R.A. 4-8-2-A light Mountain type locomotives which have a tractive effort of 53,900 lb., 27 in. by 30 in. cylinders, total weight 327,000 lb., 224,500 lb. on drivers and

fit them better for the speeds at which the passenger trains are scheduled and lateral motion driving boxes were applied on the front pair of drivers to lessen the rigid wheel base and eliminate the trouble with hot bearings. These modifications naturally necessitated a longer boiler which would tend to increase the weight beyond that allowable. The previous engines had a rated boiler horsepower capacity of 97.5 per cent of the cylinder horsepower. In order to keep the weight

COMPARISON AND RATIOS OF THE MISSOURI PACIFIC'S NEW LOCOMOTIVES

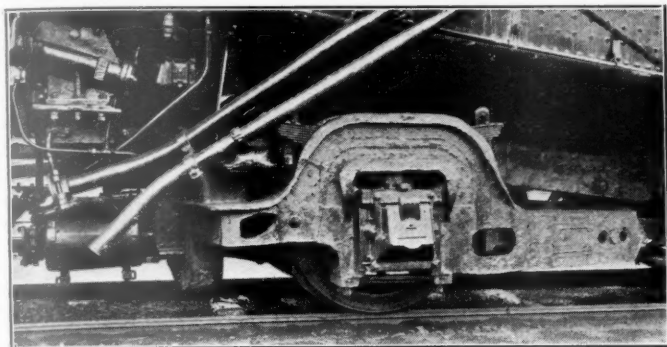
	0-6-0 Switcher	2-8-2 Mikado†	4-6-2 Pacific	4-8-2 Mountain
Tractive effort (85 per cent).....	39,100 lb.	59,800 lb.	39,500 lb.	53,500 lb.
Cylinders, diameter and stroke.....	21 in. by 28 in.	27 in. by 32 in.	26 in. by 26 in.	27 in. by 30 in.
Valves, size and kind.....	10 in. piston	14 in. piston	14 in. piston	14 in. piston
Greatest travel.....	6 in.	7 in.	6½ in.	7 in.
Lap.....	1 in.	1½ in.	1½ in.	1½ in.
Exhaust clearance.....	1 in.	0	1 in.	1 in.
Lead in full gear.....	0	½ in.	1 in.	1 in.
Weight in working order:				
On drivers.....	163,000 lb.	233,000 lb.	166,500 lb.	226,000 lb.
On front truck.....	.....	30,500 lb.	49,000 lb.	52,500 lb.
On trailing truck.....	.....	56,500 lb.	52,000 lb.	56,500 lb.
Total engine.....	163,000 lb.	320,000 lb.	267,500 lb.	335,000 lb.
Total engine and tender.....	287,800 lb.	510,000 lb.	435,700 lb.	527,800 lb.
Wheel base, driving.....	11 ft. 6 in.	16 ft. 6 in.	13 ft. 0 in.	19 ft. 7 in.
Rigid.....	11 ft. 6 in.	16 ft. 6 in.	13 ft. 0 in.	12 ft. 8 in.
Total engine.....	11 ft. 6 in.	36 ft. 3 in.	33 ft. 7 in.	41 ft. 4 in.
Total engine and tender.....	43 ft. 10½ in.	71 ft. 1½ in.	67 ft. ¾ in.	77 ft. 2 in.
Wheels and journals:				
Driving, diameter over tires.....	51 in.	63 in.	73 in.	73 in.
Driving journals, main.....	9½ in. by 12 in.	12 in. by 13 in.	10½ in. by 12 in.	12 in. by 13 in.
Driving journals, front.....	9 in. by 12 in.	10 in. by 13 in.	10 in. by 12 in.	10 in. by 19 in.
Driving journals, others.....	9 in. by 12 in.	10 in. by 13 in.	10 in. by 12 in.	10 in. by 13 in.
Boiler, style:	Ext. Wagon Top	St. Top	Ext. Wagon Top	Conical Cenn.
Diameter, inside first ring.....	64½ in.	88 in.	72½ in.	76½ in.
Steam pressure.....	190 lb.	190 lb.	193 lb.	210 lb.
Firebox, length and width.....	78 in. by 70¼ in.	114½ in. by 84¼ in.	108 in. by 66 in.	114½ in. by 84¼ in.
Grate area.....	38 sq. ft.	67 sq. ft.	49.5 sq. ft.	67 sq. ft.
Tubes, number and diameter.....	158—2 in.	199—2½ in.	207—2 in.	182—2½ in.
Flues, number and diameter.....	24—5½ in.	45—5½ in.	32—5½ in.	40—5½ in.
Tubes and flues, length.....	14 ft.	19 ft.	20 ft.	22 ft.
Heating surface, firebox.....	145 sq. ft.	263 sq. ft.	207 sq. ft.	300 sq. ft.
Heating surface, arch tubes.....	.....	27 sq. ft.	26 sq. ft.	27 sq. ft.
Heating surface, tubes.....	1,149 sq. ft.	2,214 sq. ft.	2,155 sq. ft.	2,346 sq. ft.
Heating surface, flues.....	480 sq. ft.	1,223 sq. ft.	895 sq. ft.	1,261 sq. ft.
Heating surface, total evaporative.....	1,774 sq. ft.	3,727 sq. ft.	3,283 sq. ft.	3,934 sq. ft.
Superheating surface.....	393 sq. ft.	1,051 sq. ft.	778 sq. ft.	1,084 sq. ft.
Equivalent heating surface*.....	2,363 sq. ft.	5,303 sq. ft.	4,450 sq. ft.	5,560 sq. ft.
Tender:				
Water capacity.....	6,000 gal.	10,000 gal.	8,000 gal.	10,000 gal.
Fuel capacity.....	10 tons	16 tons	14 tons	16 tons
Ratios:				
Weight on drivers ÷ tractive effort.....	4.3	3.9	4.2	4.2
Total weight ÷ tractive effort.....	4.3	5.3	6.8	6.3
Tractive effort ÷ equivalent heating surface.....	16.5	11.3	11.3	9.6
Tractive effort × diameter drivers ÷ equivalent heating surface.....	844	711	823	702
Equivalent heating surface ÷ grate area.....	62.3	79.2	89.9	83.0
Weight on drivers ÷ equivalent heating surface.....	68.9	43.9	37.4	40.6
Total weight ÷ equivalent heating surface.....	68.9	60.4	60.3	60.3
Firebox heating surface ÷ equivalent heating surface, per cent.....	6.1	5.0	4.6	5.4
Volume of cylinders, cu. ft.....	11.2	21.18	15.96	19.86
Equivalent heating surface ÷ volume cylinders.....	211	250	278	280
Grate area ÷ volume cylinders.....	3.4	3.2	3.1	3.4
Superheater surface ÷ evaporative surface, per cent.....	22.1	28.2	23.7	27.5

*Equivalent heating surface = total evaporative heating surface + 1.5 times the superheating surface.

†The weights and ratios for those without booster.

on the Mikado type. Boosters were not applied but provision was made for their attachment in the future.

As has been stated, the Pacific and switch engines are practically the same as previous engines but are provided with Harter circulating plates. The Pacific type locomotives



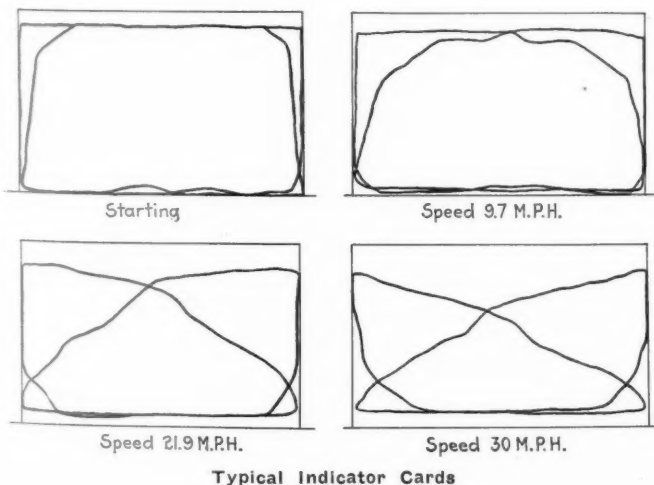
Booster and Delta Truck Used on Mikado Locomotives

are operating with exhaust nozzles from $\frac{1}{2}$ in. to $\frac{3}{4}$ in. larger than was previously possible and are showing an improved fuel record and better performance in general than the older design of locomotives.

A table showing the principal dimensions and ratios of the four types of locomotives is given for comparison with other designs.

Long Stroke Cylinder Tests on Southern Pacific

In the description of the new locomotives of the 4-6-2 and 2-10-2 types for the Southern Pacific given in the *Railway Mechanical Engineer*, August 1921, attention was called to the use of long piston stroke which was adopted as the result of a series of experiments. The new locomotives of the 4-6-2 type have 25 in. by 30 in. cylinders with $73\frac{1}{2}$ in. driving wheels whereas the older engines have 22 in. by 28 in. cylinders with $77\frac{1}{2}$ in. wheels. The new locomotives



Typical Indicator Cards

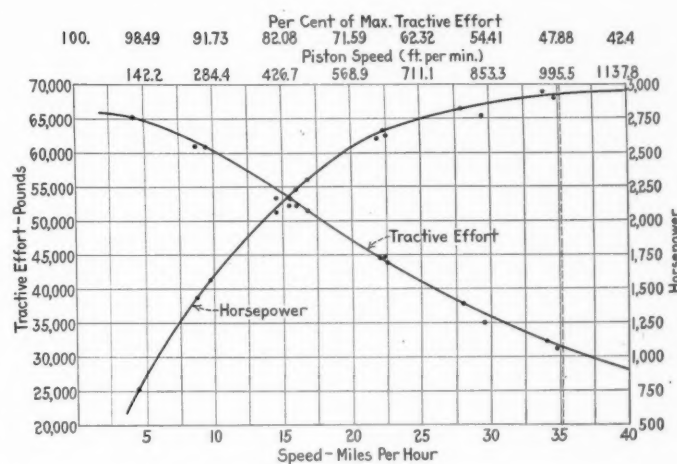
of the 2-10-2 type had $29\frac{1}{2}$ in. by 32 in. cylinders and the older engines $27\frac{1}{2}$ in. by 32 in. cylinders, both designs having $63\frac{1}{2}$ in. wheels. These changes give the new Pacific type locomotives 13.2 per cent higher piston speed for the same running speed and whereas the older locomotives have a piston speed of 1,000 ft. per min. when running at 49.5 m. p. h. the new locomotives have the same piston speed when running at 43.8 m. p. h. For heavy mountain passenger service on long grades up to 1.5 per cent, the higher relative

piston speeds are giving better results, as would be expected from the fact that the maximum horsepower of superheated locomotives is obtained at a piston speed of approximately 1,000 ft. per min. or higher.

To determine the effect of the long stroke on the mean effective pressure developed, a number of the tests were made with 2-10-2 type locomotives, Southern Pacific Class F-1, built in 1917 and 1919. These engines have a rated tractive effort of 65,300 lb. at 85 per cent of the boiler pressure, weigh 348,000 lb., of which 273,000 lb. is on the drivers, and have $63\frac{1}{2}$ in. wheels (new), or about 63 in. at the time of the tests. Other leading dimensions were given in the tabulation on page 482 of the *Railway Mechanical Engineer*, August 1921.

In connection with the tests it may be of interest to add that the valves were of the piston type, 15 in. diameter, greatest travel $7\frac{1}{4}$ in., lap $1\frac{1}{4}$ in., exhaust clearance $\frac{1}{8}$ in., and lead in full gear $\frac{1}{4}$ in.

Indicator cards were taken of both cylinders at various speeds up to 35 m. p. h. Four typical cards are shown herewith which were taken when starting and at speeds of approximately 10, 20 and 30 m. p. h. The following table



Horsepower and Tractive Effort Curves

gives the results calculated from these and a number of other cards.

Speed, m. p. h.	Steam pressure, lb.	Mean effective pressure, lb.	Tractive effort, lb.	Reverse lever notch
Starting	198	173.4	65,790	Corner
4.35	200	171.9	65,230	Corner
9.7	198	159.7	60,600	5
15.5	200	137.8	52,290	9
21.9	200	117.4	44,550	11
24.5	200	105.3	39,940	10
30.0	199	88.8	33,700	12
34.8	200	82.5	31,300	12

Curves showing the horsepower and the tractive effort at various speeds were plotted from the indicator cards and the dynamometer car records. As these curves are particularly interesting, one of them is shown. The recorded starting tractive effort of 66,000 lbs. corresponds well with the nominal rated tractive effort of 65,300 lbs. based on 85 per cent of the boiler pressure. The maximum horsepower developed was 2,950. This corresponds to one horsepower for every 118 lbs. of the locomotive weight, a very satisfactory proportion.

In view of the high mean effective pressures shown by the indicator cards and the excellent horsepower and tractive effort results, the use of long stroke cylinders appeared to be well warranted. Results obtained from the new engines which have now been in service for some time are reported to fulfill all expectations.

Informal Meeting of Traveling Engineers

Hiring of Firemen, Conservation of Supplies and Operation of Locomotive Devices Discussed

THE Traveling Engineers' Association held an informal meeting on September 7 and 8, 1921, at the Hotel Sherman, Chicago. At this meeting, which took the place of the regular annual convention of the association, postponed on account of prevailing business conditions, the reports of a number of the committees which were to have been presented before the regular convention were read and discussed and officers were elected for the ensuing year.

In calling the meeting to order the president, W. E. Preston, Southern Railway, spoke in part as follows:

President Preston's Address

Have you watched the sea in a great storm and noted the waves, mountain high, as they dash against the shore? And have you noted that for hours after the storm has passed and the sky is clear and the wind has ceased to blow, the waves still roll quite as high? The storm has passed, but the effects of the storm still remain.

For four years 40,000,000 men quit peaceful occupations and undertook to destroy each other, together with all the property they could reach. For those who did not go to war was assigned the great task of feeding and clothing those who fought and supplying the implements of warfare. No one has yet even guessed the cost of the conflict. We know that millions of lives were lost, and that the accumulated savings of centuries of industry were wiped away. The conflict is past, but we are left with waves of unrest, with our social and industrial life impaired, with the wreckage of a great storm to clear away.

Civilization is expensive. It costs effort and economy to create the wealth that will support modern life. The world problem is to replace that which was destroyed, that the comfort and security of civilization may be passed on to future generations. There is but one way to meet this cost. That which was destroyed was the product of labor of hands and brains, and was saved through centuries of economy. It is our task to work and save, simple virtues, but real wealth is only created when men work and save.

The contribution of the members of the Traveling Engineers' Association is to supply at minimum cost an article which the modern world stands in great need of—transportation. The world is far short of its demands. Ocean transportation was nearly swept from the seas by the great war. Transportation by highways is growing by leaps and bounds, but will never replace the service that was rendered by the railroads. During the past ten years our population has increased more than 15 per cent, but from the day the world was plunged into war the railroads have been unable to increase terminals, to better their road beds or to improve roll-

ing stock. Members of our organization occupy key positions in supplying this sorely needed commodity—transportation. We are always on the firing line, in the front line trenches. But back of us is a great army of loyal engineers and firemen, trained for their jobs, strong, ready, capable.

The great world need is that men in all walks of life shall work harder and save more of what they produce. The world needs that every locomotive shall work to its full capacity the maximum number of hours each year, at the minimum cost of operation. Not alone for this year, but for years to come, must we contribute our big share to replace what has been destroyed.

Now is the time to stick close to the rigid rules of common honesty, to remember the ten commandments and keep them. The honest man will not accept a day's pay until he has done a day's work. There must be the same honesty in dealing with the corporation as with the individual. The world needs the spirit of Christianity permeating the lives and actions of men. The measure of a man must be not how much wealth has he taken into his own safety vaults, but how much has he done in his generation to quiet the unrest, to put right the wrong, to house and feed and give comfort to a world whose civilization has been strained near the breaking point.

The world looks to us in America to safeguard the sacred right of man to own property, secure against all interference except by due process of law. It is the law that makes us free. Can you picture a railroad whose trains ran at random, at the mere whim of the engineer, who might claim that because this is a free country he had the liberty to run his train how, when and where he pleased? It is because he and all engineers obey the law that he becomes a free man. He has the freedom of the road when all obey the law.

New Officers Elected

The report of the secretary showed a membership of 1,546, representing a gain of 87 members during the year. The following officers were elected: President, J. H. DeSalis, New York Central; first vice-president, Frederick Kerby, B. & O.; second vice-president, T. F. Howley, Erie; third vice-president, W. J. Fee, Grand Trunk; fourth vice-president, J. N. Clark, Southern Pacific; fifth vice-president, J. B. Hurley, Wabash; secretary, W. O. Thompson, New York Central, and treasurer, David Meadows, Michigan Central. No change was made in the membership of the executive committee except the addition of W. E. Preston, Southern, the retiring president.

Abstracts of two of the reports and discussions follow. Others will appear in later issues.

Conservation of Supplies and in Operation of Locomotive Appurtenances

The subject of the conservation of supplies is logically divided into two parts; First, the conservation at the terminal, and second, conservation on the road.

A suitable building located at the point where all engines arrive and depart, materially affects the conservation of supplies at the terminal. This is where all equipment is kept to supply engines for service. The equipment is checked to the engine crews prior to their departure, and checked in again upon their arrival. This facilitates the keeping of a complete record at all times and enables the party in charge

of equipment to account for it if any should be lost or destroyed. If the engine crews know they will be held responsible for the use of supplies upon their arrival at terminals, it will act as an incentive for them to take better care of the equipment.

Where the engines are in pool service, the engineer going out should have an opportunity of seeing the work reported by the incoming engineer. This will give the outgoing man the information that is essential for the proper care of any work that has been done. He will also have a knowledge

of defects that have been reported, which the shop forces were unable to attend to and he will thus be able to protect himself and the company from injury.

The adequate supply of lubricant for the trip should be considered highly essential to the conservation of machinery and appurtenances on the engine. Worn cylinders and valve bushings can often be charged to improper lubrication. However, this is seldom due to the fact that an insufficient amount of oil has been furnished. It is more often caused by defects that have not been reported or defects that have been reported and repairs not made. Also, instructions are not always carefully followed as to the right method of lubricating the machine, or perhaps the man in charge is indifferent.

In order to conserve supplies on the road it is imperative that engines be equipped with proper receptacles so that the different articles, such as oil, waste, lanterns, flags, water glasses, fusees and torpedoes, will not be wasted and damaged if not used. If all concerned were advised as to the cost of supplies or the enormous amount of money involved, it would be an incentive to all concerned for their judicious use and care. The co-operation of the employees is paramount. Carry no equipment on the engine that is not required. All surplus equipment should be promptly reported and removed at the home terminal.

Overloaded tenders are dangerous and extravagant, and overflowing tanks at water plugs are wasteful and expensive, for in freezing weather the water often overflows the tracks, which is very dangerous indeed, as well as expensive to clear away.

Enginemen should make intelligent reports as to locomotive conditions; that is, reports by means of which the enginehouse organization is capable of locating the precise defects. Reporting defects in a general way should not be tolerated, and enginemen should be encouraged to make proper reports by having the work done promptly or if the work cannot be done on this trip the engineman should be so advised and the work followed up and done for the next trip. This will encourage enginemen not to grow lax in making detailed reports.

Power Reverse Gears

We wish to note particularly the air losses of the power reverse gear. In many instances adequate forces have not been furnished to maintain this appliance and there are heavy air losses as a result of improper care. With the necessary care this device would result in a saving of fuel and water, as the engineer can adjust the cut-off with so much less exertion. However, with heavy air losses around the rotary and by the cylinder packing, it is next to impossible to regulate the cut-off at short valve travel, which results in the engine being worked at a longer cut-off, with a corresponding excess of consumption of fuel.

Once the steam has been used instead of the air for operating the gear it is of no more use until the piston is repacked.

Piston packing rings improperly cut, and failing to lap properly cause creeping. Also, if they are too tight and hardened, the rubber having lost its resiliency they will not keep tight contact with the cylinder wall.

Hardened packing in the piston gland, scored rod or worn parts—any blow here will cause creeping.

Leaky drain cocks or cylinder oil cups will cause creeping.

On some gears there are cone-shaped valves for the distribution of air to the power reverse and these valves cause considerable trouble because of leaks, which will cause creeping when the reverse lever is hooked up. Leaky rotary valve will also cause this trouble; however, this seldom gives any trouble. Cases have been found where the stop pin is broken off and wedged between the rotary faces, damaging them; but under ordinary wear the rotary stands up well.

When the reverse gear valve assembly is changed, it is ab-

solutely necessary to check the length of the long connection rod to the cylinder lapping lever. In some cases it had to be changed in length as much as $1\frac{1}{2}$ in. Failing to do this the links will touch bottom at one end and have too short maximum cut-off in the other end.

Lost motion in pins and connecting rods of the reverse should not be tolerated.

Owing to the fact that the gear receives most of its wear in hooked-up position, in time the cylinder increases in diameter at that part of the stroke and the piston rod decreases in diameter at the corresponding place. A gear that is worn this way will be a constant source of trouble from creeping and jumping.

Rotary, cylinder and connecting rod pins should be well oiled. Make sure that the steam shut-off valve is not leaking condensation into the reverse.

Cases have been found where the long connecting rod had several bends in it. This rod should be of sufficient size to avoid bending.

Locomotive Headlight Equipment

Any engineer operating locomotives equipped with electric headlights should make this a part of his study, in connection with his other duties. He should see before leaving the terminal that the dynamo has been well oiled and cared for and that his headlight is equipped with incandescent globes, also that he has sufficient lights placed in proper position in the cab, in order to furnish light to all the equipment he has to handle. He should bear in mind that the dynamo is the most vital part of the equipment and that he should pay particular attention to the condition of this machine at all times, keeping constantly in mind that all the bearings should be kept oiled. The governor will get out of order once in a while and will not control the speed of the machine as it should. When this condition develops, if the engineer does not take notice, it will result in the cab lights being burned out, especially if the headlight is cut out from the switch in the cab. In order to handle this situation, the engineer should throttle the machine down by the throttle in the cab. The engineer should bear in mind that if his hours are long in making the run over the division, at night, the machine should be lubricated between terminals. He should also see that his headlight is properly focused. There is no one who has a better opportunity of keeping the headlight properly focused than the engineer. After completing the trip, if there are any conditions about this equipment causing it not to function properly, he should make an intelligent report and have conditions properly cared for at the terminal before the engine is allowed to go out again.

The Superheater

Enginemen should be taught the disastrous effects of carrying high water with this device. It not only converts the appliance into a steam dryer, but is very apt to cause the unit joints to leak and also to form a coat of lime or sediment on the inside of the tube, which substantially affects the degree of superheat obtained. It has been discovered that in extreme cases of carrying water too high in the boiler the superheat units have become completely clogged. Moreover, superheater headers have been broken, due to an excessive amount of water or filling the boiler too full while the engine was laying up at terminals.

Enginemen should receive instructions to closely observe the operation of the damper, for if the damper does not close when the throttle is closed, the superheater units will become overheated and will not only cause the unit joints to leak, but will have a tendency to crack the return bends and thus cause a complete engine failure.

The committee deems it best to place an independent lubricator on the locomotive for the purpose of lubricating the

stoker engine or motor, placing it convenient to the fireman. We do not wish to relieve the engineer of the responsibility of caring for this machine when on the line of road, but the fireman should be held responsible by the engineer for the proper care of this machine. It will in a measure fit him for greater responsibilities in the future. The fireman should see that all parts are lubricated while on the line of road, and where the coal is not prepared he should watch closely for any foreign matter which would be liable to cause a stoker failure. The engine crew should see that the conveyor hopper is empty on arrival at the terminal and all slides closed. This will prevent the conveyor being overloaded or clogged when the engine is coaled.

The report is signed by J. P. Russell (chairman), Southern; J. A. Mitchell, N. Y., N. H. & H.; W. J. Fee, Grand Trunk; H. E. Reynolds, C. R. I. & P., and E. Von Bergen, Illinois Central.

Discussion

The discussion of this report was confined almost entirely to the methods of handling locomotive supplies and tool equipment. E. Von Bergen (Illinois Central) described a monthly report which is being made up to show the amount of supplies issued to various engine crews, from which any cases of excessive issues may readily be determined and in-

vestigation made to learn the cause and apply corrective measures. The discussion disclosed a lack of uniformity in the methods of checking supplies on and off locomotives. In some cases they are checked both at the outgoing and the incoming terminal. In other cases they are checked out and in at the home terminal only. The use of individual tool boxes of convenient size which can be handled by the enginemen has met with considerable success in conserving the small tools required on locomotives, the engine crews showing considerable interest in taking care of this equipment. In any case the greatest trouble is experienced in looking after the tools while the engines are in the terminal. This is particularly true where the tools are assigned to the locomotive and are taken off after the crew leaves the engine by the supply room attendant.

One advantage which has developed from providing private tool boxes for the enginemen is the incentive which this provides each engineman to accumulate a few tools of his own with which he will make repairs on the road that otherwise would not be made.

The greatest difficulty is experienced in conserving the issues of torpedoes and fuses, one reason being that it is difficult to determine closely the number of occasions arising which actually require their use as intended.

Self-Adjusting Wedge, Feed Water Heater and Booster

The present standard wedge is of the manually adjusted style. It is designed to take up the wear between the driving boxes and the shoes and wedges brought about by the up and down movement between the frame and the boxes. This wear, if not taken up, results in undue freedom of the box between the shoe and wedge. This lost motion is the cause of the so-called "box pound" due to the movement of the box backward and forward between the shoe and the wedge. This brings about a side wear of the crown brasses and a tendency to break these bearings. The hammer-like blows struck against the shoe and wedge by this backward and forward movement of a loose box may result in broken shoes and wedges, and these blows become a prolific cause of broken frames. This lost motion of the boxes, which usually affects the different wheels unequally, tends to cause a variation from the distance intended in the locomotive design in the distance between the centers of the rod bearings. The main driving boxes, due to the greater thrust brought to bear upon them, as a rule, develop the most wear. This wear of the main driving boxes throws undue strain on the side rod bearings, tending to cause rod pounds, broken side rod bushings and brasses, and possibly bent and broken side rods.

Lost motion in connection with main wheel driving boxes tends to increase the steam piston stroke and shorten the steam cylinder clearance space at the end of stroke, and when allowed to become extreme may bring about cylinder knocks due to the steam piston striking the cylinder heads with a tendency to knock them out. Lost motion of the main driving boxes is taken up by the steam piston at the beginning of its stroke and live steam is thereby permitted at any given valve cut-off to follow the piston further than intended, thus causing a loss in expansion value of the steam, and a loss of fuel.

The taking up of lost motion existing in main driving box parts through steam piston pressure moves the main driving wheels bodily back and forward to the extent of such lost motion, thus setting up a tendency for the wheels to slip during this movement. This is claimed to be a most common cause of wheel slipping and of troubles in that connection in moving heavy trains, especially where the rails are bad or conditions adverse.

That these results of failure to prevent undue lost motion

of the driving boxes in the frame are frequently the cause of locomotive failures and always a source of increased maintenance cost is too well known to require further comment.

The engineman has always been held responsible for allowing any such undue lost motion, and until within the past few years usually attended personally to the setting up of the adjusting wedges. The most that is expected of him today is that he shall report any looseness or pounding of the driving box parts, the actual work of setting up the wedges, devolving on the roundhouse forces. This condition has not brought about a change for the better.

When the engineman himself took care of this work, it was his practice to so spot the locomotive that the driving boxes were forced up against the shoes, thus giving all possible free play between the driving boxes and the wedges and permitting the wedges to be forced up to the extent necessary to eliminate all lost motion; the wedge was then slightly pulled down to provide the required freedom of movement of the box and to prevent its sticking. It is now not uncommon practice in roundhouses for employees assigned to do this work upon report of the engineman to undertake to adjust the wedges without moving the locomotive at all, thus frequently not fully accomplishing the object desired and thereby permitting the locomotive to return to service in a condition detrimental to itself and the railroad.

The value of a self-adjusting wedge, simple in its design and non-erratic in its action, will readily appeal to all who have to do with either the handling of the locomotive or its maintenance. To the engineman it would mean a more efficient and satisfying machine, to the mechanical department an incalculable benefit in the savings effected in maintenance cost through the tendency to prevent the many troubles herein mentioned as arising through failure to properly keep up the wedges and through the reduction of locomotive failures due to these causes as well as a very considerable saving in the cost of roundhouse labor now required to do the adjusting of wedges, and doing it none too efficiently. In which direction the savings would lay, would, of course, depend largely upon the previously existing conditions.

At first glance, the designing of such a wedge seems quite simple and easily brought about through the placing of a suitably arranged spring underneath the adjusting wedge

and operating on it in such manner as to gradually force up the wedge as lost motion develops in the driving box parts. It is understood that this method, without any change in the adjusting wedge other than adding to it of such a spring and the small parts necessary to give the required spring tension, has been tried out on at least one large railroad. In giving this method a second thought, however, we are likely to look for what we understand actually occurs, that of the wedge being gradually tightened until it grips the box, causing a hard riding locomotive and possible rough usage of the rail as a consequence. This, of course, means the curing of one evil at the expense of acquiring another one practically as bad.

A method of preventing this gripping of the box has been brought forward in a self-adjusting wedge now being used to an increasing extent on many of our railroads. In this device the adjusting wedge is made in two parts which might appropriately be referred to as an adjustable wedge and a floating wedge. The adjustable wedge is tapered on one side to suit the taper of the frame jaw with a reverse taper on its opposite face. The floating member is also tapered, its thickest part being at its upper end, and it fits between the adjusting wedge and the driving box. A wedge bolt, attached to the adjusting wedge as usual, passes down through the pedestal binder and has attached to it below the binder the adjusting spring and the parts necessary to give this spring the required tension. The floating wedge is made of such length that when fitted into the driving box jaw, there is not less than 3/16 in. nor more than 5/16 in. clearance or play for it to move up and down between the pedestal binder and the frame. With this arrangement, if the driving box should move up in the frame jaw, there would be a tendency for it to carry the floating wedge with it in case there was any clearance between the top of the floating wedge and the top of the frame jaw. On account of the tapers of the two wedge parts this would tend to bring about a loosening of the driving box between the shoe and wedge. Before this could be effected, however, the small clearance given the floating wedge between the pedestal binder and the top of the frame jaw would bring the top of the floating wedge up against the top of the jaw, checking any further tendency to cause undue freedom of the box as the floating wedge would then be held stationary even if the box continued to rise in the frame jaw. If the driving box should move down in the frame jaw the tendency would be to carry the floating wedge with it and at the same time there would be a tendency to force down the adjusting wedge against the spring tension. This would bring about a loosening of the driving box between the shoe and wedge. The limited clearance space of the floating wedge in the frame jaw, however, would cause the lower end of the floating wedge to strike the binder and prevent further tendency to cause undue freedom of the box, as the floating wedge would then be held stationary even if the box continued its downward movement.

Reports from several of our members located on roads having this device in use and who have had actual experience with it, as well as from several mechanical superintendents on roads having it in use, state that it gives excellent results.

While any type of self-adjusting wedge is supposedly automatic in its action, it must be remembered that none are automatic in maintenance. Like all mechanical devices they require a certain amount of attention, the labor required, for such attention being, of course, considerably less than is necessary for looking after manually adjusted wedges. The principal attention to self-adjusting wedges should be for regular lubrication, absolutely necessary with any type of wedge, and the adjustment of the adjusting spring.

It is impossible to give accurate figures on the savings in cost of upkeep of the frame, box parts and runnings gears

as between engines having manually adjusted wedges and ones with self-adjusting wedges for the reason that many troubles with these parts which could be caused by poorly maintained driving box parts might also be due to other causes. However, a table prepared by an eastern railroad shows in a general way results obtained from locomotives of same type with self-adjusted wedges of the type just referred to.

[The table gave in detail the amount of rod work required on 20 locomotives of the 2-10-2 type equipped with the self-adjusting wedges, from July 18, 1920, to January 31, 1921, during which period the engines aggregated 408,447 miles, or slightly more than 20,000 miles each. Four engines, aggregating 83,800 miles, received no rod work whatever. Eight engines, aggregating 161,865 miles, received complete rod work. On the remaining eight locomotives 12 No. 3 brasses, 8 No. 2 brasses, and one set of main bushings were renewed. No crown bearing or wedge material was used.—EDITOR.]

Feed Water Heaters

From 55 per cent to 58 per cent of all heat generated in the firebox is lost in exhaust steam. This great loss of heat is due to the necessity of exhausting steam from the steam cylinders while still in its gaseous form and to the fact that it requires about 970 heat units simply to hold water in the form of steam, all of which, together with such additional heat units as may be in the exhaust steam, is allowed to pass out of the locomotive stack without doing any additional work other than acting as a draft on the fire.

Considerable success has been achieved in heating feed water for boiler use by means of exhaust steam. It is our understanding that this practice has long been successfully made use of in connection with stationary boilers; also, that it is used to a considerable extent in European countries on locomotives. Germany alone is said to have 10,000 locomotives equipped and to be adding this equipment at the rate of 2,000 feed water heaters per year. That this method has not received more consideration in this country in the past has probably been due to cheap fuel and lack of an efficiently developed device for the object in view.

Generally speaking, feed water heaters making use of exhaust steam are of two kinds known as the closed type and the open type. In the open type the exhaust steam either goes directly into the feed water, and in condensing gives up its heat to the water or goes through tubes surrounded by the feed water, heating this water while being itself condensed in the tubes. When it goes directly into the water it is found advisable to pass the exhaust steam through an oil separator enroute to the feed water heater to prevent lubricating oil contained in exhaust steam from entering the locomotive boiler. In this type the heater is open to atmospheric pressure and the pump is placed between the heater and the boiler check. In the closed type the water is forced through tubes in an enclosed heater, these tubes being surrounded with exhaust steam which heats the water as it passes through the tubes. In this type the heater is between the pump and the boiler check and is subject to boiler pressure.

In the open type on account of the heater being open to atmospheric pressure the feed water can be heated only to the normal boiler temperature of 212 deg. F. In the closed type it is possible to heat the water to within 10 to 15 deg. of the temperature of the exhaust steam, which may run as high as 250 deg. F.

About one-sixth or 15 per cent of the exhaust steam which would ordinarily go out through the locomotive stack is diverted to the use of the feed water heater.

One type of heater which has been applied to probably one-half of the American locomotives so far equipped has an arrangement whereby after the exhaust steam going to

the heater has been condensed, this water can be filtered, freeing it of any lubricating oils that it may contain, and be returned either to the locomotive tender or into the suction pipe of the pump carrying the feed water to the heater. By this means it is claimed that the tender water capacity is in effect increased 10 per cent to 15 per cent.

That a large fuel saving and actual increase in boiler efficiency will result from such installation seems to be generally believed. The economical results obtained are due not only to the fact that a large amount of the heat from the exhaust steam is reclaimed, but also because the rate at which the fuel is burned on the grate is reduced.

Our information is that some eighteen of our American railroads are today using or experimenting with feed water heaters, although not to exceed seventy-five locomotives all told are equipped, and that five different types of feed water heaters are being tried out. Owing to the limited number in use and the time used, reliable figures as to the average cost of maintenance of such devices are not available, but it is believed it will be well within the bounds of reason as compared to the savings which it is believed can be brought about by their use.

A summary of a number of runs made with a freight locomotive on the New York division of the Erie Railroad equipped with a feed water heater of the closed type heater, as compared with the same number of runs using the injector, is shown in one of the tables. A summary of nine runs with feed water heater and nine with the injector, in passenger service with a locomotive on the D. L. & W., equipped with the same type of feed water heater, is also shown.

SUMMARY OF ERIE RAILROAD FEED WATER HEATER TESTS

Direction of runs	Heater West	Injector West	Heater East	Injector East
Length of runs—miles.....	88.3	88.59	89.22	89.44
Actual running time—dec. hours.....	4.75	5.436	5.658	5.699
Number of cars, including dynamometer car.....	70	74	80	87
Actual tons, including engine and tender..	1,957	1,988	5,029	4,943
Coal fired per locomotive mile.....	211	245	203	241
Average steam pressure.....	173	172.0	173.1	172.7
Average superheat.....	579	597	571	600
Maximum superheat.....	606	641	604	640
Water evaporated per pound coal as fired, running time.....	7.917	6.867	7.697	6.529
Water evaporated, per lb. dry coal, R. T.	7.965	6.909	7.735	6.609
Equiv. evap. per lb. dry coal, R. T.	9.270	8.070	9.007	7.772
Total coal fired, running time.....	18,635	21,705	18,151	21,574
B. t. u. per lb. coal as fired.....	13,279	13,702	13,357	13,225
Boiler efficiency, based on dry coal, per cent.....	67.34	57.0	65.1	56.3
Coal fired, running time, to operate feed water pump.....	231	....	225	....
Water evaporation per lb. coal as fired, running time, based on equal B. t. u.'s (13,225).....	7.885	6.628	7.621	6.529
Per cent saving in coal as fired, running time, in favor of feed water heater.....	18.96	....	16.72	....
Per cent total coal fired to operate feed water pump.....	1.24	....	1.24	....
Per cent net saving in coal as fired, R. T. in favor of feed water heater.....	17.72	....	15.48	....
Average feed water temperature.....	71	65	71	60
Average temperature of feed water leaving heater.....	209	....	193	....
Average temperature of feed water leaving injector.....	....	178	....	169.5
Maximum temperature of feed water leaving heater.....	231	....	239	....
Maximum temperature of feed water leaving injector.....	....	199	....	190

AVERAGE RESULTS OF NINE TESTS WITH AND NINE TESTS WITHOUT FEED WATER HEATER—D. L. & W. LOCOMOTIVE 1135, ON TRAIN No. 6

	Heater	Injector	Per cent difference for heater
Tonnage.....	527	535..	1.5 per cent less tonnage
Running time....	193	189..	2.2 per cent more running time
Total coal, lb....	9,760	12,460..	21.6 per cent less coal per run
Total water, lb....	97,919*	95,493..	2.27 per cent more water per run
Lb. water per lb. coal.....	9.97*	7.79..	28.0 per cent more water per lb. coal
Coal per ton train	18.4	23.3..	21.0 per cent less coal per ton train
Water per ton train	186.	180..	1.67 per cent more water, ton train

* 12 runs.

The Locomotive Booster

The locomotive booster is designed to assist in starting such standing trains as the locomotive is capable of hauling on a level track when once in motion without the aid of such device, but which it would otherwise be unable to start without assistance of some kind and for helping it to haul

such trains over ordinary grades encountered between terminals; to assist in starting trains out of places where stops are necessary, as at stations, towers, water plugs, switches, etc., or where made necessary by locomotive or train troubles, and which, on account of curvature or grade, are bad places to start from and ordinarily would require the taking of the train slack, perhaps backing up to a place from which a start could be made, setting off of cars, doubling of grade, or obtaining the assistance of another locomotive.

While the addition of a booster increases the tractive effort of the locomotive and thereby makes possible the starting of additional cars and to that extent serves to increase the tonnage which can be hauled under normal conditions or serves to assist in getting heavy trains over the road without delays on grades and at bad starting places, it is in no sense intended as an aid in permitting the overloading of the locomotive to a point beyond what its normal capacity would be when in motion on a level track without this device, as this would make additional aid again necessary in starting from terminals, bad starting places enroute and on ascending grades.

The method of operation is simple. The engineman decides that he needs the booster, he raises the booster latch, which makes contact with the control valve, and the booster is automatically engaged. The booster cuts out automatically when the reverse lever is moved back from the corner, which is at a speed of approximately 12 to 15 miles an hour, or it may be cut out instantly by the engineman knocking the booster latch down, which is similar to knocking out an electric switch.

The claims made for the booster are that it puts any locomotive with trailing wheels into the next class above in starting effort, because the trailing wheels act as an additional pair of drivers; that on freight trains this means more tons handled annually because of greater starting effort and acceleration, and avoids damage to machinery and equipment because of a smooth, steady start; that on passenger trains it means smooth starting and quick acceleration to road speed, protects the equipment from damage and renders schedules more easily maintained by avoiding delays in starting; that it reduces by one-half the time required to get trains to road speed and that it pays its own fixed and maintenance charges several times in doing this through reduced wear and tear on rods, pins, cross-head keys, tires and other parts of the machinery of the locomotive that would ordinarily be caused by slipping in the effort to start, and that when the train is up to road speed it has no more effect on the locomotive's operation than so much coal on the tender.

The following record of a run made on the West Shore line will give a good general idea of the benefits claimed for the booster as shown in actual performance. Engine 3149 left Ravena with a crew that had no previous experience with the booster and the intention was to determine whether or not the full tonnage of 2,582 to 2,600 could be taken through to Weehawken without the usual reduction to 2,100 tons at Newburgh. The booster was used on all starts as well as on grades at speed.

The first test was at Catskill where water was taken, the water plug being located at the bottom of two grades, the ascending one being .39 per cent. The usual practice was to leave the train at the top of the west grade, cut off and run for water, then come back, hook up and make a run for the other grade. This practice was disregarded and the train was hauled down to the water plug. After taking water the booster was cut in and the train carried over the grade at satisfactory speed. With the booster cut in, 5 miles per hour was quickly gained with the draw-bar pull showing 41,067 lb., and for a distance of 580 ft. the speed increased from 5 to 8½ miles per hour. The booster was then disengaged and the locomotive required to take the load entirely and the draw-bar pull dropped to 33,497 lb., or a difference of

7,570 lb. in favor of the booster. This represented 22 per cent increase in draw-bar pull. The throttle and reverse lever were not touched.

The train continued on to Kingston and at each stop the booster was cut in for starting and showed rapid acceleration. The ruling grade is at Haverstraw, six miles long and an average of .47 per cent. A stop was made for water and the train started with the booster. When the grade was reached the speed was 33 miles an hour. On the grade the first mile showed a speed of 28½ miles an hour; the second mile a speed of 19 miles an hour, the third mile a speed of 12 miles an hour, the fourth mile a speed of 8 miles an hour, and the fifth mile a speed of 7½ miles an hour.

Speed was falling very rapidly and at the end of the fifth mile the draw-bar pull registered 36,441 lb. The booster was then engaged where the grade was .52 per cent and in 432 ft. the speed was 8 miles an hour and the draw-bar pull 42,900 lb., a difference of 6,459 lb. or 17 per cent increase with the booster. The speed then gradually rose and reached 10 miles an hour in the next ¾ mile and with tonnage of 22.6 per cent over the previous capacity of the locomotive. One and five-eighths miles of grade yet remained and when the train passed over the top the draw-bar pull showed 45,080 lb. The booster was then cut out and the train arrived at Weehawken with the original tonnage of 22.6 per cent more than this class engine had ever before taken through. A day or so later the regular crew caught engine 3,149 and, not to be outdone by the test just related, brought through 2,618 tons, representing an increase of 24.6 per cent over the ruling tonnage.

The report is signed by T. F. Howley (chairman), Erie; Frederick Kerby, B. & O.; J. P. Stewart, A. T. & S. F.; John Draney, D. L. & W., and J. A. Talty, Franklin Railway Supply Company.

Discussion

The discussion of the self-adjusting wedge indicated that there had been little experience with locomotives having com-

plete installations of the device among the members present. In most cases mentioned the wedges were applied on the main drivers only. The opinion was expressed, however, that to get the full benefit of the device it must be applied on all boxes and this general application seems now to be the tendency. In caring for self-adjusting wedges the most important point, according to the experience on the New York Central, was stated by J. H. De Salis to be the proper attention to the adjustment of the springs. If these are too loose the piston force at full stroke is sufficient to force the wedge down against the spring. If the spring is too tight a stuck wedge results. These difficulties are avoided by keeping the spring adjusted to a height of 1½ in. from the jam nut to the binder. The experience of those taking part in the discussion indicates a material increase in the mileage obtained from driving boxes and better rod conditions than have been obtained with the manually adjusted wedges.

In discussing the feed water heater, J. N. Clark (Southern Pacific) stated that this company has two open type and two closed type heaters in service, one each in a bad water district and one each in a good water district. The results obtained from these installations are, however, not yet available.

In the discussion of the locomotive booster, a number of installations of this device were mentioned, all of which have demonstrated their ability to effect considerable improvement in the handling of heavy trains. W. H. Corbett stated that the Michigan Central has three boosters in service on passenger locomotives, which have eliminated jerking and the necessity for taking slack in starting heavy passenger trains and have materially increased the rate of acceleration in starting these trains up to about eight miles an hour.

A trial on the Chicago & Eastern Illinois was referred to in which a 4,383 ton train was taken over a grade, over which, without the booster with the same locomotive it was required to reduce the tonnage to 3,976. With the booster the heavier train was pulled up the grade in 19 minutes, while the light train without the booster required 23 minutes to move over the same distance.

The Effect of the Feed Water Heater on Superheat and Back Pressure

BY E. A. AVERILL

PRIMARILY the feed water heater is purely a device for improving the action of a boiler, but when it is applied to a locomotive where the action of the boiler and engines is closely interwoven, it will also have some effect on the action of the steam in the cylinders. This effect is of two kinds; one beneficial; viz., the reduction in the back pressure on the piston, and the other detrimental; viz., the reduced superheat of the steam going to the cylinders.

In all locomotives the exhaust steam passage is restricted at the nozzle tip. Thus with a definite amount of steam to be discharged from the cylinders, and the pistons moving at any selected speed, the pressure created in the cylinder back of the piston during exhaust, generally termed the back pressure, has a direct relation to the size of the tip. The smaller the tip the greater the back pressure and vice-versa.

When a feed water heater is applied to a locomotive there are two additional large openings made in the exhaust passages, which combined frequently equal the area of the tip itself. These, however, are connected to the shell of the heater which is in the form of a drum having a relatively small outlet that is water sealed. When the feed water heater is not in operation this drum is filled with exhaust steam, but little can escape and there will be no effect on the back pressure or draft. When, however, cold water is pass-

ing through the tubes of the heater, the steam in the heater body is condensed, thus reducing its volume about 1,200 times, and more steam rushes in to take its place. In this way, when the heater is in use, about 12 per cent of the exhaust steam from the cylinders is drawn off before it gets to the nozzle tip. This has somewhat the same effect as an increase of the same percentage in the size of the tip or a change in diameter from 6 in. to 6 5/16 in.

Naturally this increased opening means a reduction in the back pressure on the piston which in turn means increased power from the same amount of steam admitted to the cylinders. In order to determine just how great this increase in power might be, arrangements were made during a recent test of feed water heaters to obtain as nearly as possible the same speed and the same cut off at selected points on the run with and without the feed water heater. Indicator cards were taken at these places and as the boiler pressure was the same in all cases, exactly the same volume of steam entered the cylinder. Calculation of the indicated horsepower from the cards gave the desired information. Several sets of these cards are shown in the illustration.

It is readily seen from the appearance of the cards how much the back pressure was reduced by the heater. It is particularly interesting, in the low speed card, to note how the hump caused by the exhaust from the other side

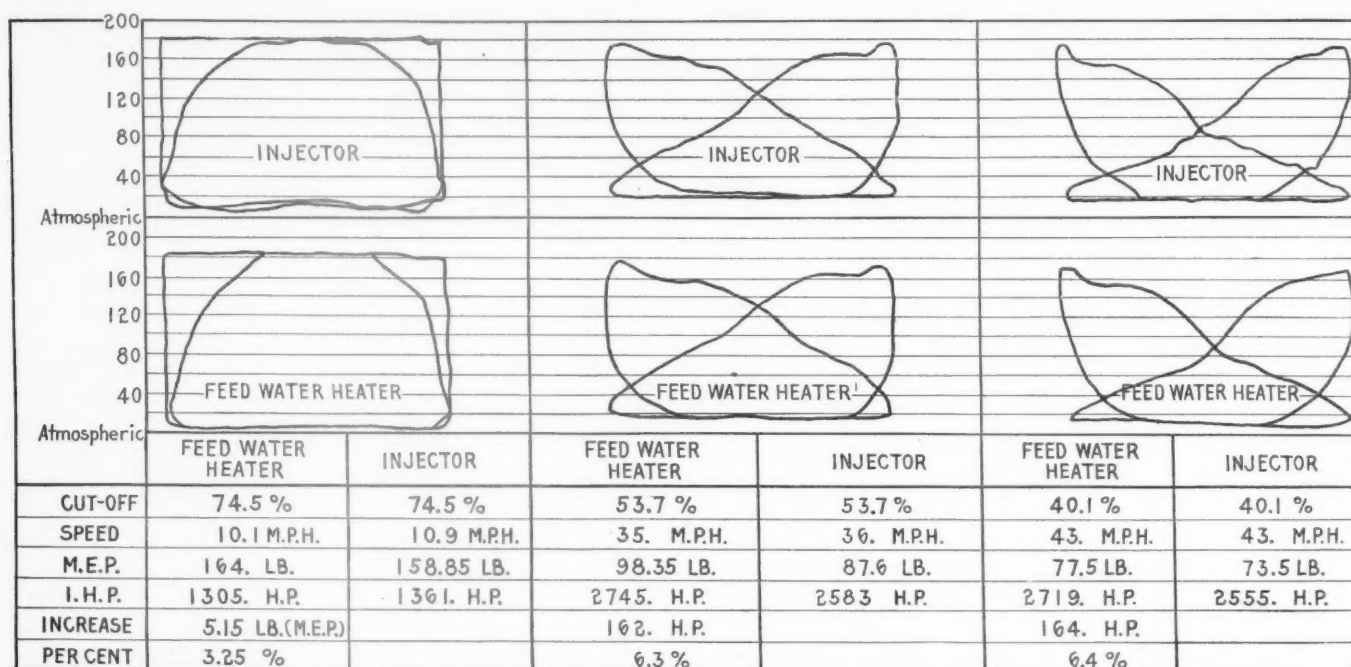
of the engine, has been smoothed out when the heater was in use.

Under each pair of cards will be found a table giving the conditions and the indicated horsepower developed, as well as the percentage of increase shown by the feed water heater. In the first pair of cards, because of an eight per cent difference in the speed, the comparisons are made on the basis of mean effective pressure. In the others the speeds are practically the same and the comparison is made on the basis of indicated horsepower.

It will be seen that the effect of the feed water heater

The reduction in superheat by 22 deg. F. means an increase of about two per cent in the weight of steam per cubic foot under the conditions on these runs. Since the cut off with and without the heater was identical, and the speed was alike, essentially the same volume of steam entered the cylinders in both cases.

Making the correction for the greater weight of the steam per cubic foot it will be found that there is a reduction of about four per cent in the pounds of steam per indicated horsepower when the feed water heater was in use over that used with the injectors. This, then is the



Comparative Indicator Cards With and Without the Feed Water Heater

has been to increase the horsepower developed by over six per cent at the highest speed, and over three per cent at the lowest speed. With exactly the same volume of steam entering the cylinder in each case the feed water heater increases the power by three to six per cent because of the lower back pressure.

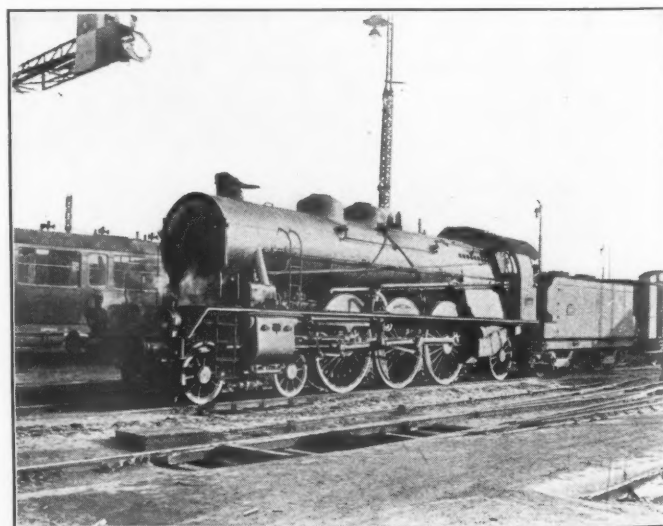
This, of course, is very satisfactory, but further investigation of the conditions should be made before the final conclusion is reached. While the same volume of steam entered the cylinders when these cards were taken, it was not at the same temperature in both cases and thus did not weigh the same per cubic foot. The steam with the feed water heater in use was not as highly superheated, and this condition must be taken into consideration.

A feed water heater will generally reduce the coal consumption for the same quantity of steam delivered from the boilers by from 13 to 15 per cent. This means that if the boiler without the heater will evaporate eight pounds of water per pound of coal, it will evaporate from 9.04 to 9.20 lb. of water with the heater in use. Thus the superheater, while passing the same quantity of steam through the units, is supplied with about 15 per cent less hot gas than before. Naturally without changing the superheater, the steam will not be as highly superheated as when the heater was not in use, and more coal was being burned to produce each pound of steam that passes through the units.

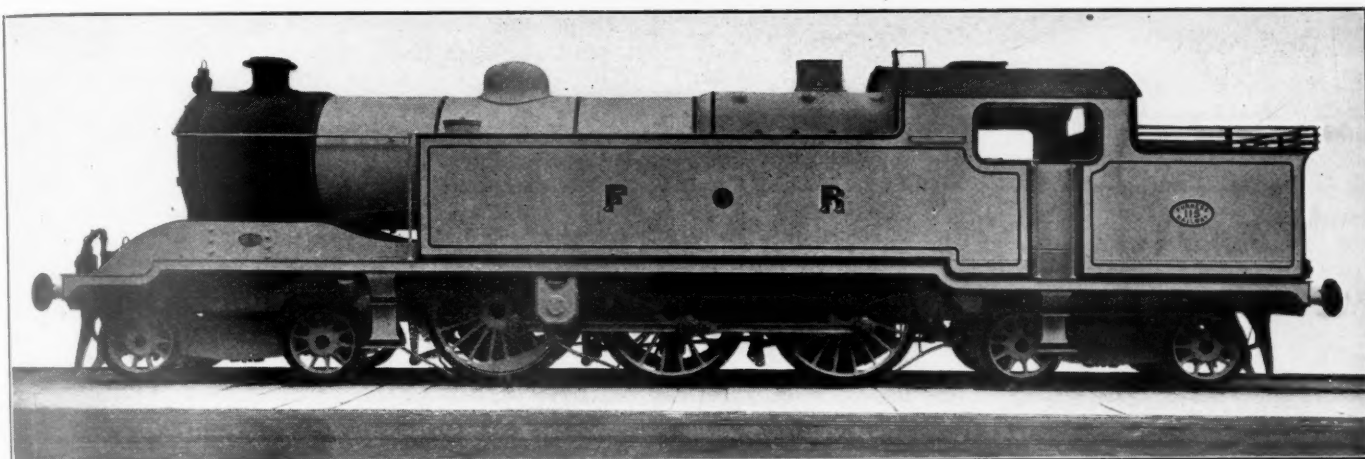
Data to determine just how large this drop in superheat may be is easy to obtain and has been taken on a number of tests. On the test mentioned above the average loss of superheat amounts to about 22 deg. F. Under conditions on other tests it has been found to vary between 20 and 30 deg. F.

net effect of a feed water heater on the cylinders and clearly indicates that there is a gain in over-all efficiency from this source in addition to the large gain obtained by the direct effect on the boiler.

OF THE TOTAL RAILWAY MILEAGE in the United States rather over 1 per cent is operated electrically as against about 4 per cent in Britain.—*South African Railways & Harbors Magazine*.



Pacific Type Locomotive on the Paris, Lyons and Mediterranean



Heavy Tank Locomotive of 4-6-4 Type for Furness Railway; Built by Kitson and Company, Leeds, 1920

The Comparison of Dimensions and Proportions of British Locomotives

BY E. C. POULTNEY

PART TWO

*I*N the first section of this article, which appeared in the September issue of the *Railway Mechanical Engineer*, Mr. Poultney discussed the factors used in comparing various types and designs.

General Considerations

When comparing the dimensions of locomotives of various types and considering the abilities of their boilers to supply the power required as expressed by Boiler and Boiler Demand Factors, it is necessary to consider not only the relationship existing between the cylinder horsepower and the total evaporative heating surfaces, but also the disposition of the heating surfaces and also the ratio of proportion which the grate area bears to the total evaporative surface, and in the case of superheater locomotives the evaporative surface and that contributed by the superheater elements. The evaporative heating surface of a locomotive boiler is made up of two parts, the tube and the fire-box surfaces, and of these the surface of the fire-box is per unit of area the most valuable. This being so, it follows that if two boilers are compared, one having a larger fire-box than the other but each having equal total heating surfaces, and grate areas, the boiler having the larger percentage of its total surface contained in the fire-box will give the higher evaporation and for equal engine efficiencies will develop a higher horsepower per square foot of heating surface. Further, if two boilers each having equal tube and fire-box heating surfaces, but having different grate areas so that they differ by having different values of C , then at equal rates of firing the boiler having the larger grate will evaporate more water per square foot of heating surface per hour than the boiler having the smaller grate; it will not, however, be so economical; in other words, the water rate per pound of fuel fired will not be so great as with the boiler having the relatively small grate surface. The boiler having the larger grate will, however, permit of higher B and BD factors.

From the foregoing it would seem that when considering the boiler factors B and BD the proportion of the total heating surface that is contributed by the fire-box should be considered, and also the value of the factor C . When exam-

ining the boiler factors for different locomotive types it will at once be noticed that in cases where the power demand per square foot of heating surface is high, as shown by the value of the factors B and BD , the grate areas used are always large in proportion to the heating surfaces, and further, fire-box surfaces are usually larger in proportion to the total heating surfaces.

FBS

The higher values for $\frac{\text{FBS}}{\text{St}}$ are in almost all cases accompanied by a lower value for C , indicating a large grate.

Generally, a larger grate surface will mean at the same time a larger fire-box because for any given type or form of fire-box any increase in the dimensions of the grate will naturally result in a longer or a wider box which will, if the height remains unaltered, result in a larger heating surface. The ratio of proportion between the grate area and the firebox surface has already been mentioned, and its importance lies in the fact that on it depends the volumetric

FBS

capacity of the fire-box as expressed by the $\frac{\text{FBS}}{\text{GA}}$ factor.

GA

Tables of Dimensions and Proportions

Turning now to the tables of dimensions and proportions it will be noticed that a considerable number of locomotive types are covered.

Table 1—4-4-0 type Express engines—contains particulars of 17 different locomotives for 11 different railways; thus the idea of several designers can be seen. The examples are all modern designs, that is, they have been built new, or rebuilt with superheaters during the last ten years, and the same applies to the locomotives listed in the remaining tables.

As will be seen, 17 different items of information are given. The first is the name of the road, then follow 10 columns giving the principal dimensions, and the remaining 6 show how the related dimensions are proportioned to each other, and seem to be sufficiently comprehensive to enable the making of a comparative study of each different design.

The locomotives shown in Table 1 cover a wide range of

TABLE 1.
 EIGHT-WHEELED—4-4-0 TYPE LOCOMOTIVES

Railway	Total weight	Adhesive weight	Cylinders dia.; and stroke, in.	Drivers dia. in.	Steam pressure	Rated tractive effort	Total heating surface evaporative	Superheater surface	Total heating surface	Grate area	Fire-box surface per cent of total	Superheater surface, per cent of total	Adhesive weight Rated tract. effort	R.T.E. X D Total heating surface evaporative	Total heating surface Grate area	Total weight Total heating surface
	Wt.	AW	d s	D	P	RTE	S	Sh	St	GA	FBS	SH	A	HD	C	E
L. N. W.	133,840	85,120	20½x26	81	175	20,000	1,547.7	302.5	1,850.2	22.4	8.3	16.4	4.27	1,045	82.6	72.2
G. C. R.	136,600	88,500	20 x26	81	180	19,800	1,659	210	1,869	26	8.4	11.2	4.46	980	72.0	73.0
N. E. R.	133,100	91,600	19 x26	82	160	15,600	1,058.8	390.7	1,449.5	27	10.9	26.9	5.86	1,210	53.7	91.9
L. C. D. S. E.	128,700	84,500	20½x26	80	160	19,100	1,412	319	1,731	22.5	9.2	18.4	4.42	1,080	76.5	74.3
C. R.	137,200	89,040	20½x26	78	180	21,432	1,329	200	1,529	20.7	9.4	13.1	4.15	1,260	74.0	89.7
C. R.	137,200	88,816	20 x26	78	170	18,200	1,329	226	1,555	20.6	9.2	13.9	4.87	997	75.5	88.4
M. R.	119,588	77,169	19½x26	84½	175	17,200	1,172	313	1,485	21.1	7.5	21.1	4.48	1,240	70.3	80.5
M. R.	134,963	87,360	19 x26	78½	200	21,400	1,321	360	1,681	28.4	8.4	21.4	4.07	1,175	59.3	80.3
L. S. W. R.	135,336	80,724	20 x26	79	180	20,000	1,284	231	1,515	27.0	9.6	15.2	4.03	1,232	56.1	89.5
G. W. R.	123,872	80,864	18 x26	80½	200	17,900	1,352	215	1,567	20.5	8.2	13.7	4.51	1,065	76.4	78.5
L. & Y.	107,856	74,032	20 x26	87	160	18,300	886.1	209.9	1,096	18.75	9.9	19.1	4.06	1,795	58.4	98.2
L. C. D. S. E.	117,700	75,000	19 x26	78	180	18,700	1,277.9	228.0	1,504.9	24.0	8.4	15.1	4.02	1,141	62.7	78.3
G. N. R.	120,000	80,724	18½x26	80	160	15,070	972	258.0	1,230	19.0	9.75	21.0	....	1,240	64.7	97.5
N. B.	129,600	84,900	20 x26	78	180	20,400	1,285.5	355.2	1,640	21.1	8.5	21.6	4.1	1,237	75.7	79.0
G. W. R.	127,300	84,200	18 x30	8½	200	20,600	1,478	212.5	1,690	20.5	7.6	12.5	4.1	1,112	82.4	75.4
N. E. R.	123,100	80,000	19 x26	82	175	16,940	1,120	306	1,426	20.5	10.1	21.4	4.8	1,242	71.3	86.3
G. C. R.	124,700	81,200	19 x26	81	180	17,584	1,275	179	1,454	21.0	9.3	12.3	4.6	1,116	69.3	85.6
											8.8	16.7	4.25	1,126	70.0	82.7

 TABLE 2
 TEN WHEELED—4-4-2 TYPE LOCOMOTIVES

Railway	Total weight	Adhesive weight	Cylinders dia.; and stroke, in.	Drivers dia. in.	Steam pressure	Rated tractive effort	Total heating surface evaporative	Superheater surface	Total heating surface	Grate area	Fire-box surface per cent of total	Superheater surface, per cent of total	Adhesive weight Rated tract. effort	R.T.E. X D Total heating surface evaporative	Total heating surface Grate area	Total weight Total heating surface
	Wt.	AW	d s	D	P	RTE	S	Sh	St	GA	St	Sh	A	BD	C	E
N. E. R.....	172,800	80,300	16½x26*	82	175	19,161	1,475.8	530	2,005.9	27.0	8.9	26.4	4.6	1,063	74.0	85.7
G. N. R.....	156,255	80,520	20 x24	80	170	17,300	2,027.0	570	2,597	30.9	5.5	28.1	4.6	690	83.6	60.2
L. B. S. C.....	152,800	83,400	20 x26	79½	170	20,800	2,031.0	460	2,491	30.9	5.4	18.5	3.9	815	80.5	61.3
N. B.....	171,900	89,400	21 x28	81	180	23,400	1,803.8	385	2,188.2	28.5	8.4	17.6	3.8	1,051	76.7	78.5
N. E. R.....	134,400	72,600	20 x24	80	170	17,300	1,163.0	254	1,417	24.5	9.6	17.9	4.2	1,186	57.8	95.0
N. E. R.....	167,300	86,400	20 x28	82	175	20,214	1,475.8	530	2,005.9	27.0	8.9	26.4	4.2	1,123	74.0	83.5
*Three cylinders.											7.8	21.5	4.2	967	74.4	77.3
Side Tank Engines																
L. B. S. C.....	163,720	85,120	21 x26	79½	160	19,580	976	305	1,281	24.0	9.8	21.3	4.3	1,595	53.3	....
G. W. R.....	16,800	82,880	18 x30	80½	195	19,950	1,029	185	1,214	20.5	10.0	15.2	4.1	1,560	59.2	....
N. S. R.....			20 x26	72	160	19,630	1,020	261	1,281	21.0	10.7	20.3	...	1,387	61.0	....
											10.2	19.0	4.2	1,517	57.8	....

 TABLE 2A
 12 WHEELED 4-4-4 TYPE LOCOMOTIVES

Side Tank Engines																
N. E. R.....	189,840	89,600	16½x26*	69	160	20,800	1,058	273	1,331	23	9.3	20.5	4.3	1,351	57.8	....
Met. R.	172,800	87,400	19 x26	69	160	18,430	1,178	268	1,446	21.4	9.1	18.5	4.7	1,079	67.5	....
											9.2	20.0	4.5	1,215	62.6	....
*Three cylinders, simple expansion.																

*Three cylinders, simple expansion.

 TABLE 3
 TEN WHEELED—4-6-0 TYPE LOCOMOTIVES

Railway	Total weight	Adhesive weight	Cylinders dia.; and stroke, in.	Drivers dia. in.	Steam pressure	Rated tractive effort	Total heating surface evaporative	Superheater surface	Total heating surface	Grate area	Fire-box surface per cent of total	Superheater surface, per cent of total	Adhesive weight Rated tract. effort	R.T.E. × D Total heating surface evaporative	Total heating surface Grate area	Total weight Total heating surface
	Wt.	AW	d s	D	P	RTE	S	Sh	St	GA	FBS	SH	A	BD	C	E
											St	St				
L. & N. W. R.	174,300	133,200†	15½x26	81	175	23,800	1,748.7	379.3	2,128.0	30.5	8.1	17.8	5.6	1,093	69.8	81.9
G. C. R.	168,560	126,360	21½x26	81	180	22,750	2,386	440.0	2,826	26	5.9	15.5	5.5	773	108.6	59.5
G. C. R.	177,000	128,000†	16 x26	81	180	24,772	2,044	343	2,387	26	6.8	14.3	5.1	980	92	74.0
C. R.	165,556	124,736	20½x26	78	175	20,600	1,818	515	2,332	26	6.3	22.0	6.0	836	89.6	71.0
G. E. R.	143,360	97,560	20 x28	78	180	22,000	1,623	286.4	1,919	26	7.4	14.9	4.4	1,057	73.8	74.7
G. W. R.	162,300	124,100†	15 x26	80½	225	27,800	1,841.3	283.4	2,124.7	27	7.2	13.3	4.4	1,212	78.7	79.5
G. W. R.	169,306	124,100†	14½x26	80½	225	25,100	1,841.3	283.4	2,124.7	27	7.2	13.3	4.9	1,095	78.7	79.5
L. N. W. R.	148,400	94,720	20½x26	75	175	21,000	1,572.9	324.5	1,897.5	25	7.0	18.5	5.4	1,060	73.5	78.0
G. S. W. R. I.	158,368	115,136†	14 x26	79	175	18,900	1,772	440	2,212	28	7.1	20	6.0	845	78.0	71.0
L. & Y.	177,100	132,700†	16½x26	75	180	29,000	1,995	552	2,547	27	6.8	21.6	4.5	1,120	94.5	69.6
N. E. R.	158,368	120,176	20 x26	73½	160	19,200	1,821	544	2,365	23	6.08	23.0	6.2	775	103.0	66.9
N. E. R.	174,100	131,488*	18½x26	68	180	30,032	1,573	530	2,103	27	7.9	26.4	4.3	1,300	77.5	83.2
L. S. W. R.	174,300	125,100	21 x28	67	180	28,200	1,878	308	2,186	30	7.4	14.1	4.4	1,000	72.7	79.7
C. R.	168,000	126,560	20 x26	73	175	21,155	1,676	258.2	1,934	25.5	7.5	13.3	6.02	922	75.7	86.8
C. R.	181,500	134,400*	18½x26	73	180	28,000	2,370	270	2,640	28.0	6.4	10.2	4.8	864	94.2	68.8
G. W. R.	161,000	123,000	18½x30	80½	225	24,200	1,841.3	283.4	2,124.7	27	7.2	13.3	5.0	1,055	78.7	75.7
L. S. W. R.	174,500	125,300	22 x28	79	180	25,200	1,878	308	2,186	30	7.4	14.1	4.9	1,060	73.0	80.0
											7.5	16.8	5.1	1,000	80.0	75.7

†Four cylinders simple expansion. *Three cylinders simple expansion.

power. The rated tractive effort varies from a minimum of 15,070 to a maximum of 21,432 lb. It will be noticed that for locomotives having the higher boiler demand factors the combustion factor is usually high, and the amount of heating surface provided by the fire-box is usually somewhat greater, thus indicating high evaporative possibilities from the heating surface. Several examples of 4-4-0 engines have been given because this is a very much used type. It is comparatively simple in construction, and can be built to develop up to about 1,100 hp. where axle loads of 43,000 lb. and a

the only engine of its type. These locomotives have recently been built more particularly for pusher service on the famous Lickey incline of 1 in 37 (2.7 per cent) on the Midland West of England main line. Those conversant with history will recollect that when this line was first opened Norris & Co. of Philadelphia supplied some engines specially to work on the Lickey gradient.

Eight-wheeled engines of the 2-6-0 type have been introduced on some lines for freight service, and Table 6 begins by giving particulars of three different classes introduced on the Great Northern (G. N.). They illustrate three successive steps in the development of this particular type in which the weight per square foot of heating surface has been reduced from 103 to 69 lb., and the R.T.E. increased from 23,350 to 30,000 lb. The engines have been very successful, especially the larger three-cylinder series.

Table 8 contains engines having the 4-6-2 wheel arrangement. The G.W.R. engine shown is the only Pacific type tender engine running in Britain. The grate surface of 41 square feet is obtained by using a wide fire-box. The other examples are all tank engines for local passenger services.

Table 10 contains only one locomotive, a 4-6-4 type tank engine introduced for express passenger service on the London, Brighton & South Coast Railway. Two are in traffic and others are under construction.

In order that the more modern superheated steam locomotives may be compared with those using saturated steam, Table IV has been prepared in which the proportions of 31 main line engines are analyzed. The average results obtained are tabulated for comparison with the superheater

locomotives in Table V, in which the $\frac{\text{FBS}}{\text{GA}}$ and $\frac{\text{RTE}}{\text{GA}}$ factors have been added as additional information.

Naturally, the value of $\frac{\text{RTE}}{\text{GA}}$ for any given locomotive will directly depend on the $\frac{\text{BD}}{\text{RTE}}$ and the factor C , and the actual value of $\frac{\text{RTE}}{\text{GA}}$ has only been added here so that its average actual value can be shown.

Table V, giving the comparative proportions of certain typical main line locomotives should have a little attention in conclusion. Only the 4-4-0, 4-4-2, 4-6-0, 0-8-0 and 0-6-0 types are here considered.*

The interesting characteristic for the modern superheaters is the value of the boiler factor BD . This is seen to be from 17 to 25 per cent higher than the average for the engines using saturated steam.

The tractive effort of modern superheated engines is generally greater than that of the older saturated steam engines, and the following comparative statement will be of interest on this point.

COMPARATIVE R.T.E. SUPERHEATED AND SATURATED STEAM ENGINES

Engine type	Average values maximum tractive effort (R.T.E.)	
	Superheated	Saturated
4-4-0	18,700 (17)	17,800 (9)
4-4-2	19,700 (9)	19,300 (9)
4-6-0	24,000 (17)	22,950 (9)
0-8-0	30,860 (9)	29,200 (9)
0-6-0	23,700 (7)	19,000 (10)

NOTE.—The small figures in parentheses indicate the number of engines examined.

Table IV, in which the ratios of proportions of representative saturated steam using locomotives are given, has been prepared so as to give detail information as to the practice followed in the design of saturated steam locomotives, and also to enable comparisons to be drawn between saturated and superheated engines for main line service.

The 4-6-0 type locomotives shown have wheels from 62

*There were very few 2-8-0 and 2-6-0 type locomotives in service before the introduction of superheaters.

TABLE V
COMPARATIVE PROPORTIONS OF TYPICAL MAIN LINE TENDER ENGINES USING SUPERHEATED AND SATURATED STEAM

		F.B.S.F.B.S. R.T.E.							
Type	B.D.F.	C	St.	G.A.	G.A.	A	E	Reference	
Superheated... 4-4-0	1,126	70	8.8	6.2	828	4.25	82.7	Table I	
Saturated.... 4-4-0	918	72.5	8.5	6.0	830	4.3	75.3	" IV	
Superheated... 4-4-2	967	74.4	7.8	5.7	704	4.2	77.3	" II	
Saturated.... 4-4-2	717	77.7	6.9	5.5	700	4.3	67.2	" IV	
Superheated... 4-6-0	1,000	83.0	7.5	5.8	890	5.1	75.7	" III	
Saturated.... 4-6-0	833	79.4	7.1	5.4	884	5.2	76.3	" IV	
Superheated... 0-8-0	1,097	81.5	7.9	6.3	1,250	4.8	68.6	" V	
Saturated.... 0-8-0	874	80.7	7.9	6.0	1,290	4.5	72.4	" IV	
Superheated... 0-6-0	1,103	70.5	9.0	6.1	1,160	4.6	80.0	" VII	
Saturated.... 0-6-0	980	64.8	8.9	5.9	1,020	4.7	76.2	" IV	

total weight of about 135,000 lb. are allowed, and in its larger sizes the weight is low compared with the power available.

The Atlantic or 4-4-2 type express locomotives and tank engines for local passenger service having this wheel arrangement are shown in Table 2. Probably the two most interesting examples are the North Eastern three-cylinder and the Great Northern two-cylinder engines. They both handle trains of the same weight at similar speeds, and each have the same factor A but differ materially in other characteristics. The writer has traveled on engines of each design, and they are excellent steamers.

The North Eastern locomotive has a larger fire-box in proportion to the total heating surface, and the factor C is 11 per cent less. The North British (N.B.R.) locomotives are in point of actual maximum tractive force, the most powerful of their type; they are remarkably fine engines and are used for all the heaviest express services.

The 4-4-2 tank engines each have high boiler demand factors for reasons already stated. The fire-box surface is, however, comparatively large, and here again the factor C has a low value, indicating relatively larger grate areas.

Table 2A shows two examples of somewhat large four coupled tank engines for heavy local services. They are the only examples available having this wheel arrangement.

During recent years six coupled engines have come much to the fore in heavy main line passenger traffic. Table 3 gives 17 examples covering the practice followed on 9 different railways. The R.T.E. covers a range of power from 18,900 to 30,000 lb., the latter being a powerful design of 3-cylinder 4-6-0 engine recently built for express goods traffic on the North Eastern (N.E.R.).

The first example in the table is a powerful class of engine used in heavy express service on the London & North Western. These engines can maintain 1,400 i.hp. Another powerful type is shown by the third example. This is a four cylinder engine, several of which are now running on the Great Central (G.C.R.) and yet another is shown in the seventh example. This is a four cylinder type of which a number are in use on the Great Western. The writer has observed the working of each of these different designs from the footplate. They are good steamers and ride splendidly.

The Caledonian Railway three-cylinder engine is not at the time of writing in service. The weights given are therefore estimated.

Tables 4 to 7 inclusive, give the comparative particulars of goods or freight traffic engines.

The Midland 0-10-0 locomotive is interesting as being

to 80 in. diameter, and the R.T.E. varies from 27,000 to 18,600 lb. In Table 3 superheated locomotives the R.T.E. varies from 30,000 to 18,900 lb. and further, the R.T.E. of 11 out of the 17 examples is over 22,000 lb.

This increase in rated tractive effort has carried with it a corresponding increase in the heating surfaces, so that the modern superheated locomotives show a slightly better factor *E* than the older and smaller saturated steam engines.

ticular type of engine was not so largely used, and such when employed were generally less powerful than the modern superheaters.

On the other hand, the rated tractive effort of superheated and saturated steam engines of the 4-4-0 type is much the same, showing little increase for recent superheated designs. This is due to the fact that in many instances this class had already been built up to the limits imposed by allowable

TABLE 4
TEN-WHEELED—2-8-0 TYPE LOCOMOTIVES

Railway	Total weight	Adhesive weight	Cylinders dia.; and stroke, in.	Drivers dia. in.	Steam pressure	Rated tractive effort	Total heating surface evaporative	Superheater surface	Total heating surface	Grate area	Fire-box surface	Superheater surface,	Adhesive weight	R.T.E. × D	Total heating surface	Total heating surface
											per cent of total	per cent of total	Rated tract. effort	Total heating surface evaporative	Grate area	Total weight	Total heating surface
	Wt.	AW	d s	D	P	RTE	S	Sh	St	GA	FBS	SH	A	BD	C	E
											St	St				
G. N. R.	171,100	149,100*	18 x26	56	170	32,600	2,080.5	430.5	2,521	27.5	6.4	17.0	4.5	880	91.6	67.8
G. N. R.	170,688	150,080	21 x28	56	170	31,750	2,084	570	2,654	27	6.1	21.1	4.7	850	77.3	64.3
G. C. R.	161,280	154,360	21 x26	56	170	29,500	1,691	318	2,009	26	7.6	15.3	4.9	977	77.1	80.2
G. C. R.	170,240	154,560	21 x26	56	180	30,814	1,815	308	2,123	26	8.1	14.5	4.9	952	81.7	80.0
G. W. R.	152,996	138,660	18½x30	55½	225	35,200	1,841.3	286.6	2,127.9	27	7.2	13.4	3.9	1,060	79.0	71.7
S. D. J. R.	135,030	125,496	21 x28	55½	190	36,360	1,321	360	1,681	28.4	8.9	21.4	3.3	1,525	59.0	80.3
G. W. R.	174,800	156,300	19 x30	68	225	30,600	1,841.3	330	2,171.4	27.0	7.1	15.2	5.1	1,129	80.3	80.5
											7.3	16.9	4.4	1,053	77.9	74.9

TABLE 4A
TEN-WHEELED—0-10-0 TYPE LOCOMOTIVES

M. R.	164,900†	164,900†	16½x28	55½	180	43,312	1,718.2	445	2,163.2	31.5	7.3	20.6	3.8	1,400	68.8	76.0
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TABLE 5
EIGHT-WHEELED—0-8-0 TYPE LOCOMOTIVES

N. E. R.	147,650	147,650	20 x26	55½	175	27,985	1,370	544	1,915	23.0	7.5	28.4	5.2	1,127	83.3	60.0
N. E. R.	160,380	160,380*	18½x26	55½	180	36,960	1,573	530	2,103	27	7.9	26.4	4.3	1,295	77.5	76.2
L. N. W. R.	134,000	134,000	20½x24	53½	160	27,800	1,772.4	378.6	2,151.0	23.6	6.8	17.6	5.1	840	91.0	61.6
L. & Y.	149,128	149,128	21½x26	54	180	34,000	2,063	396	2,459	25.6	7.9	16.1	4.3	890	96	60.7
G. N. R.	124,900	124,900	21 x26	56	160	27,700	1,164	307	1,471	24.5	9.3	20.8	4.5	1,335	60	84.8
											7.9	21.8	4.7	1,097	81.5	68.6

*Three cylinders, simple expansion.

†Four cylinder simple expansion locomotive specially built for banking or pusher services.

The remarks made regarding the 4-6-0 type apply also to the freight engines of the 0-8-0 type, the increased size of the superheated engines being reflected in the smaller factor *E*. It will be noticed that the largest difference in rated tractive effort is shown by the 4-6-0 type locomotives. The reason is that prior to the advent of superheating, this par-

weights, and therefore when superheated such engines were not materially increased in power, but more economical working attained from the fact that the same or slightly greater power was obtained from an evaporative heating surface about 20 per cent less than that used by saturated steam locomotives of similar size.

TABLE 6
EIGHT WHEELED—2-6-0 TYPE LOCOMOTIVES

Railway	Total weight	Adhesive weight	Cylinders dia.; and stroke, in.	Drivers dia. in.	Steam pressure	Rated tractive effort	Total heating surface evaporative	Superheater surface	Total heating surface	Grate area	Fire-box surface per cent of total	Superheater surface, per cent of total	Adhesive weight Rated tract. effort	R.T.E. × D Total heating surface evaporative	Total heating surface Grate area	Total weight Total heating surface
	Wt.	AW	d s	D	P	RTE	S	Sh	St	GA	FBS St	SH St	A	BD	C	E
G. N. R.....	138,200	115,900	20 x26	68	180	23,350	1,118	229.5	1,347.5	24.5	10.1	17.0	4.9	1,423	55.0	103.0
G. N. R.....	144,200	118,500	20 x26	68	180	23,350	1,629.5	305	1,934.5	24.0	7.8	15.7	5.1	988	80.6	74.6
G. N. R.....	169,800	134,400*	18½x26	68	180	30,000	1,901	407	2,308	28.0	7.9	17.7	4.5	1,055	82.3	69.6
L. B. S. C.....	142,240	123,648	21 x26	66	170	25,800	1,295	279	1,574	24.8	8.8	17.7	4.8	1,315	63.5	90.3
G. S. W. R.....	139,060	122,784	19½x26	60	180	23,700	1,491	211	1,702	26.2	8.6	12.4	5.1	953	65.0	81.6
G. W. R.....	138,900	120,100	18½x30	68	200	25,700	1,478.3	212.5	1,690.9	20.5	7.6	12.5	4.6	1,183	82.5	82.0
S. E. C. D. R....	131,936	112,896	19 x28	66	200	25,700	1,525.6	203	1,728.5	25	7.8	11.6	4.3	1,112	69.3	76.3
C. R.	122,700	104,332	19½x26	60	160	19,424	1,189	266.9	1,455.9	20.6	8.1	18.2	5.3	981	72.0	84.2
											8.1	15.3	4.2	1,112	72.4	82.3

*Three cylinders—simple expansion.

TABLE 7
SIX WHEELED—0-6-0 TYPE LOCOMOTIVES

G. C. R.	116,600	116,600	18½x26	62	180	21,620	1,258	139.0	1,397	19.0	9.3	9.9	5.4	990	73.2	83.5
G. E. R.	122,700	122,700	20 x28	59	180	29,044	1,632.6	201.6	1,834.2	26.5	7.8	10.9	4.2	1,048	69.2	66.8
M. R.	109,984	109,984	20 x26	63	160	22,490	1,170	313	1,483	21.1	8.4	21.1	4.8	1,210	70.7	74.0
H. & B.	114,672	114,672	19 x26	60	170	22,600	1,100	217	1,317	19.6	10.0	16.5	5.0	1,232	72.6	86.9
L. & Y.	99,120	99,120	20 x26	61	180	26,500	870	191	1,061	18.75	10.1	18.0	3.7	1,860	57.7	93.4
N. B.	122,500	122,500	19½x26	60	165	23,300	1,407.6	324.6	1,732.2	19.2	8.2	18.7	5.2	995	87.5	70.7
N. E. R.	96,300	96,300	18½x26	55½	160	21,412	860	265.0	1,125.8	17.0	9.7	23.5	4.4	1,377	66.3	85.6
											9.0	16.9	4.6	1,103	70.5	80.0

Use of Factors in Designing

The factors which are proposed as being satisfactory for the purpose of making comparisons of different locomotives are also of use when considering the preliminary design of an engine for a given service.

Illustrating this by an example and specifying certain provisions as follows: Required the chief dimensions of an express 4-4-2 type locomotive to develop a tractive effort at the rim of the drivers at 60 m.p.h. of 7,500 lb.

$$HP. = \frac{T \times V}{375} = \frac{7,500 \times 60}{375} = 1,200 \text{ hp.}$$

Drivers are to be, say, 81 in. dia. At 60 miles per hour (240 r.p.m.) and with superheated steam, from 1.3 to 1.5 sq. ft. of evaporative heating surface will be sufficient (for saturated steam 2 sq. ft. or a little less would be wanted)

The diameter and stroke of the cylinders will of course be easily arranged after the steam pressure of the boiler has been decided.

Equivalent Heating Surface

The equivalent heating surface, or in other words the amount of heating surface that an engine using saturated steam should have, would be by the usual formula

$$2,100 + \frac{420}{2} = 2,310 \text{ sq. ft.}$$

At 2 sq. ft. of heating surface per hp. this would furnish 2,310

$$\frac{2,310}{2} = 1,155 \text{ hp.}$$

This is less by some 3½ per cent, but is near enough to

TABLE 8
TWELVE WHEELED—4-6-2 TYPE LOCOMOTIVES

Railway	Total weight	Adhesive weight	Cylinders dia. and stroke, in.	Drivers dia. in.	Steam pressure	Rated tractive effort	Total heating surface evaporative	Superheater surface	Total heating surface	Grate area	Fire-box surface per cent of total	Superheater surface, per cent of total	Adhesive weight Rated tract. effort	R.T.E. × D Total heating surface evaporative	Total heating surface Grate area	Total weight Total heating surface
	Wt.	AW	d s	D	P	RTE	S	Sh	St	GA	FBS	SH	A	BD	C	E
<i>Pacific Type Tender Engine</i>																
G. W. R.	214,910	134,400†	15 x 26	80½	225	27,800	2,855.8	545	3,400.8	41.8	5.3	16.0	4.8	755	81.3	63.2
†Four cylinders simple expansion.																
<i>Side Tank Engines</i>																
G. C. R.	191,640	120,960	20 x 26	67	160	21,600	1,431	214	1,649	21.0	8.7	13.0	5.6	1,010	78.5	....
L. N. W. R.	172,480	98,560	20 x 26	68½	175	22,400	1,085.4	248.2	1,333	23.9	10.7	18.5	4.3	1,410	55.8	....
L. B. S. C.	198,160	122,000	21 x 26	79½	170	20,800	1,585.8	357.0	1,742.8	25.16	6.4	18.3	5.8	1,043	17.4	....
C. R.	205,296	123,100	19½ x 26	69	170	19,486	1,516	200	1,716	21.5	7.0	11.6	6.2	887	79.7	....

TABLE 9
TWELVE WHEELED—2-6-4 TYPE LOCOMOTIVES
Side Tank Engines

G. C. R.	212,800	134,400	21 x 26	61	180	29,000	1,547	304	1,851	26.0	8.5	16.4	7.3	1,143	71.2	....
S. E. C. D. R.	184,900	118,200	19 x 28	72	200	23,800	1,525.6	203	1,728.6	25.0	7.8	11.7	4.9	1,122	69.0	....
											8.1	14.0	6.1	1,132	70.1	....

TABLE 10
FOURTEEN WHEELED—4-6-4 TYPE LOCOMOTIVES
Side Tank Engines

L. B. S. C.	223,000	127,000	22 x 28	80	170	24,200	1,687	383	2,070	26.6	7.3	18.5	5.2	1,146	77.6
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to develop one hp. Assume 1.4 sq. ft. and factors as follows:

Weight on drivers

$$A = \frac{\text{Rated tractive effort}}{\text{R.T.E.} \times D} = 4.2$$

Rated tractive effort

R.T.E. × D

$$BD = \frac{\text{Heating surface}}{\text{Heating surface} + \text{superheating surface}} = 960$$

Heating surface

$$C = \frac{\text{Heating surface} + \text{superheating surface}}{\text{Grate area}} = 75$$

Heating surface + superheating surface

$$E = \frac{\text{Grate area}}{\text{Total weight}} = 77 \text{ lb.}$$

Heating surface + superheating surface

Fire-box surface, 7 to 8 per cent of total.

Superheating surface, 20 per cent of total.

Total evaporative heating surface:

$$1,200 \times 1.4 = 1,680 \text{ sq. ft.}$$

$$\text{Superheating surface} = 420 \text{ sq. ft.}$$

$$\text{Total} = 2,100 \text{ sq. ft.}$$

$$\text{Grate area} = 28 \text{ sq. ft.}$$

$$\text{Fire-box surface, 7.5 per cent of total} = 158 \text{ sq. ft.}$$

$$1,680 \times 960$$

$$\text{R.T.E.} = \frac{81}{20,000} = 20,000 \text{ lb.}$$

$$81$$

$$\text{Total weight} = 162,000 \text{ lb.}$$

$$\text{Adhesive weight} = 84,000 \text{ lb.}$$

show that the formula, purely empirical as it may be, is near enough to give a fair idea of heating surfaces of superheated and saturated steam locomotives of the same horsepower.

Quite naturally the foregoing computations can be much upset if the power per unit of heating surface is greatly different, but the figures given will be found to be closely correct under average conditions, and for boilers having the average proportions adopted in estimating the size of the proposed 4-4-2 locomotive.

Conclusion

The tables of dimensions have been compiled from particulars given of the locomotives mentioned in various technical journals, principally *The Engineer*, *Engineering*, and *The Railway Gazette*, and some of the data has kindly been furnished by the locomotive engineers of the various railways.*

It will be understood that the examples might have been multiplied in number, but the aim has been to tabulate representative designs of modern power operating at the present time on British railways, and also to put forward a suggested means of comparing the various locomotives.

*The writer is indebted to the chief mechanical engineers of the Great Central, Great Northern, North Eastern, North British, and South Eastern & Chatham Railways, who have kindly supplied information relative to their locomotives.

Recent Developments in the Storage of Coal*

There has been very little activity in connection with the storage of coal by railroads since the last report of the Storage Committee.

The Fairbanks-Morse Company report of the completion of three locomotive coaling stations, including yard storage of coal, built for the Erie. At Salamanca, New York, the coaling station consisted of four circular concrete bins of 1,000 tons capacity and tributary storage for 38,000 tons. A similar plant was built at Hornell, New York, with tributary ground storage for 33,000 tons. A 300-ton coaling station was also built for the Jacksonville Terminal Company at Jacksonville, Florida, where 300 tons is stored in overhead pockets and 2,500 tons on the ground.

All of these plants were of the drag scraper type which has been largely used by the Southern Railroad and has been described in previous reports of the committee. As to cost of operation of such plants, F. P. Drinker, manager, engineering department, Fairbanks-Morse Company, says that in 1914 observations of the operation of some of the plants on the Southern Railway showed that the cost of handling coal in and out of yard storage, including power and supplies and maintenance, averaged about $2\frac{1}{2}$ cents each way, or 5 cents per ton, delivered to locomotives, and that this would indicate on the same basis a handling cost of from 10 cents to 12 cents per ton at the present time.

The Roberts & Schaefer Company report the development of a new type of storage in connection with the RandS portable coaling and cinder plant which is shown in the illustration. This type of coaling and storage plant may be equipped with a large capacity hoist or a small capacity hoist. A price for the structure complete above the rails and electrically operated, is quoted as follows:

For large capacity hoist.....	\$36,670
For small capacity hoist.....	34,490

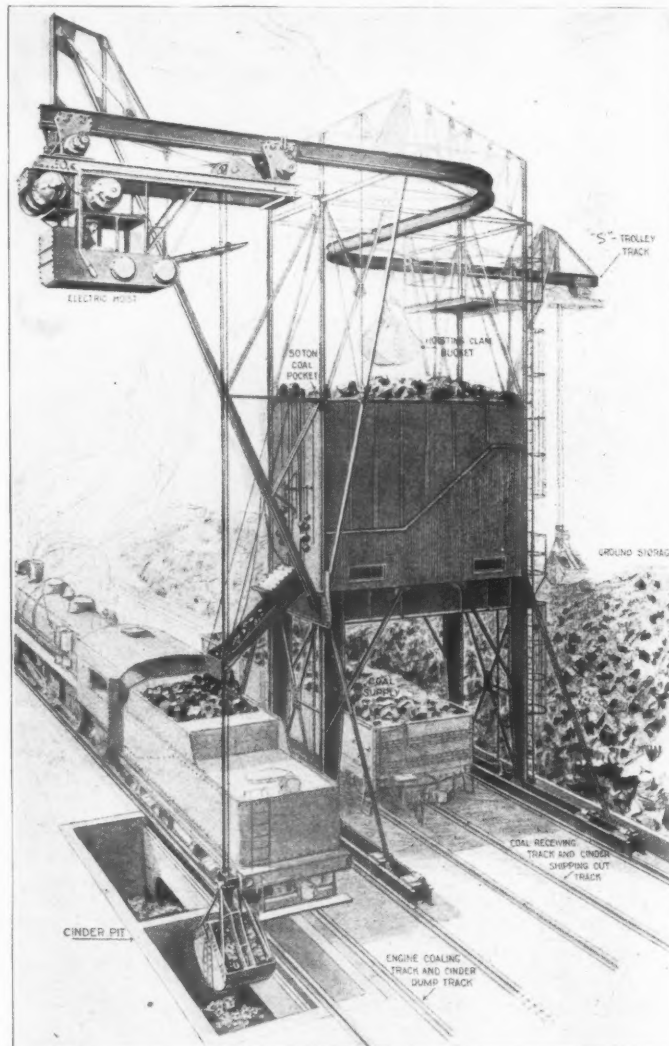
No figures are available at this time for the cost of operation of the storage portion of this plant for it is difficult to obtain separate storage figures due to the fact that many of the railroads do not attempt to separate storage and coaling costs.

The Portable Machinery Company, Passaic, New Jersey, reports an installation of portable conveyors for the Atlantic Coast Electric Railway, Asbury Park, New Jersey. The pile contains about 3,000 tons and the Atlantic Coast Electric Railway reports that it can store 350 tons a day with four men unloading and attending the conveyors. The company reports that during the past two years it has built up a similar pile at four different times and later removed it to the station. At the other end of the power plant the company has a similar storage pile.

The Consumers' Fuel Company, Morgantown, W. Va., built in 1920 a Thornley storage plant. A number of inquiries in regard to storage of coal at the mines have been received, but a number of companies that have investigated the subject have concluded that such storage is not advisable unless an increased car rating may be obtained by the mining company as a result of such storage facilities. The general public and the large users of coal should have impressed upon them the fact that storage at the mine is not of any particular assistance to the railroads or to the consumers of coal in providing coal under emergency conditions, but acts merely as a safety valve upon operating conditions at the mine. The proper place to store coal to relieve the railroads and the consumer is as near as possible to the point of consumption.

The committee feels that one of the greatest problems is to get the higher railroad authorities to thoroughly understand

the importance of the storage of coal and that they may appreciate the necessity for careful and systematic storage. Spasmodic attempts to store coal have always proven unsatisfactory both to the consumer and to the producer and that storage of coal may be successful it must be conducted regularly and in a methodical manner and by the fullest co-operation of producers, carriers and consumers. The storage proposition must be tied up with production to such an extent that it will co-ordinate properly, and when large stocks of coal have been stored the production and movement will have to be regulated in such a way that the storage coal can be used most advantageously and not become simply a high priced inventory article. The experience of the past three or four years shows conclusively that storage of coal must



Storage Plant in Connection With RandS Portable Coaling Station and Cinder Plant

be more carefully considered and that only by such careful consideration can it become the stabilizing influence that it should.

If a practicable plan of storage at large distributing centers had been operating during 1919 it is probable that the November strike of that year would not have produced the condition of panic that followed during the spring and summer of 1920.

The report is signed by H. H. Stoeck (University of Illinois), chairman; A. H. Davies, C. G. Hall (Walter Bledsoe & Co.); J. B. Hutchison (Texas Steel Co.); B. P. Phillippe (Penn System); R. E. Rightmire (Consolidation Coal Co.); A. P. Wells (Central of Georgia); H. Woods (Colorado & Southern); S. L. Yerkes (Grider Coal Sales Agency).

*From the 1921 report of the standing committee on storage coal of the International Railway Fuel Association.



Chesapeake & Ohio Gondola Coal Car of 100 Tons Capacity

100-Ton Coal Cars for the Chesapeake & Ohio

High Capacity Cars Adopted for Handling Export
Coal—Drop Doors Provided for Emergency Unloading

THE Chesapeake & Ohio handles a very large amount of export coal from the West Virginia and eastern Kentucky fields. The total tonnage which this road dumped at Newport News in 1920 was 7,264,000 tons, which was exceeded only by the Norfolk & Western. The pier is

preventing these cars from being loaded for interchange points.

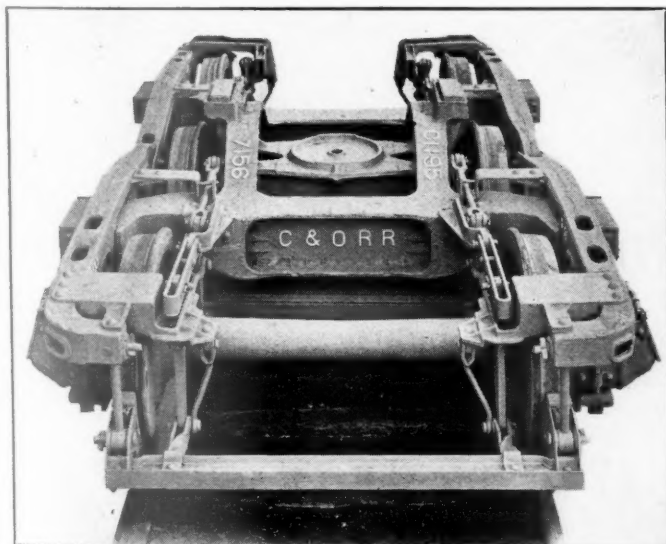
To facilitate the handling of tidewater traffic, the Chesapeake & Ohio last year ordered 1,000 cars of 100 tons capacity, of which 500 were built by the Pressed Steel Car Company and 500 by the Standard Steel Car Company. These cars are of the flat-bottom, high-side, gondola type and ordinarily will be unloaded by car dumpers. They are provided, however, with four drop doors which permit them to be unloaded in case of emergency at points where dumpers are not installed.

Of the three large roads which deliver coal to points on Hampton Roads, the Chesapeake & Ohio and the Norfolk & Western recently have adopted cars of 100 tons capacity, while the Virginian is using cars of 120 tons capacity. Both of these designs have been described in previous issues of the *Railway Age*.

Construction of the New Cars

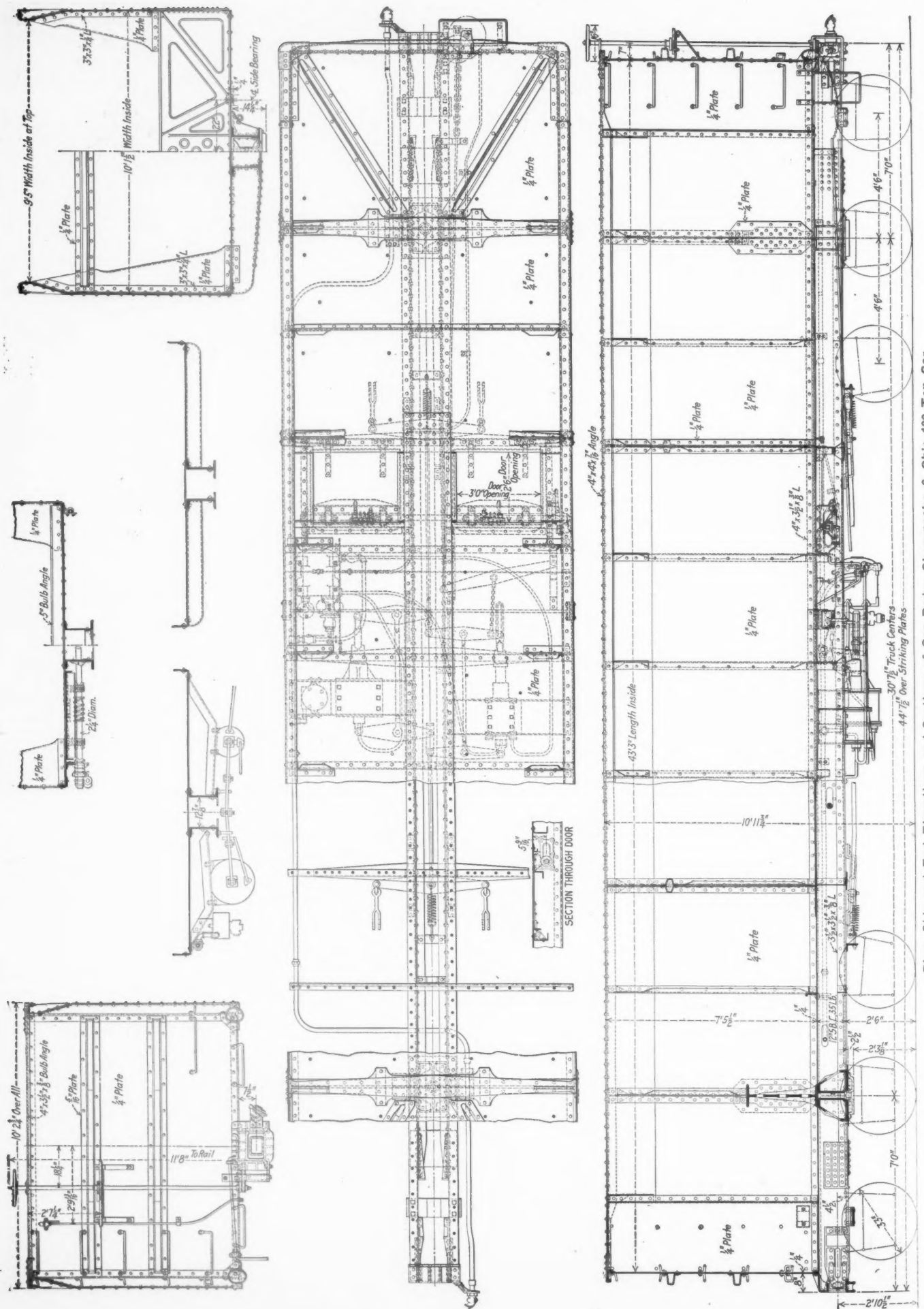
The inside dimensions of the new 100 ton capacity cars are 43 ft. 3 in. long, 10 ft. 1½ in. wide and 7 ft. 5½ in. deep. This gives a coal space of 3,212 cu. ft. when level full, or 3,703 cu. ft. when heaped at an angle of 30 deg. Using a factor of 54 lb. per cu. ft., the heaped load would weigh 200,000 lb. The cars, however, are stenciled as of 182,000 lb. capacity to provide for a 10 per cent overload. The length over striking castings is 44 ft. 7½ in.; the maximum outside width is 10 ft. 3⅝ in., and the height from top of rail to top of sides is 11 ft. The distance from center to center of the trucks is 30 ft. 7½ in. and the trucks, which are of the Lewis six-wheel type, have a wheelbase of 9 ft. The light weight of the car is 68,300 lb. and the weight on each axle with the car loaded is 44,717 lb.

The center sills are made up of two 12-in., 35-lb. channels with flanges facing out and reinforced at the bottom by 3½ in. by 3½ in. by ⅜-in. angles, extending between the draft gears, and at the top by the ¼-in. floor plates. There is



Lewis Truck with Clasp Brake

equipped with a pair of stationary turn-over car dumpers, each of which is capable of handling all sizes of cars up to those of 100 tons capacity at a rate of 30 cars an hour. The coal is dumped from the road cars into special transfer hopper cars which are lifted by an elevator, run along the pier and dumped into pockets. A large part of the export coal has been handled hitherto in hopper bottom cars of 70 tons capacity, but there has been considerable difficulty in

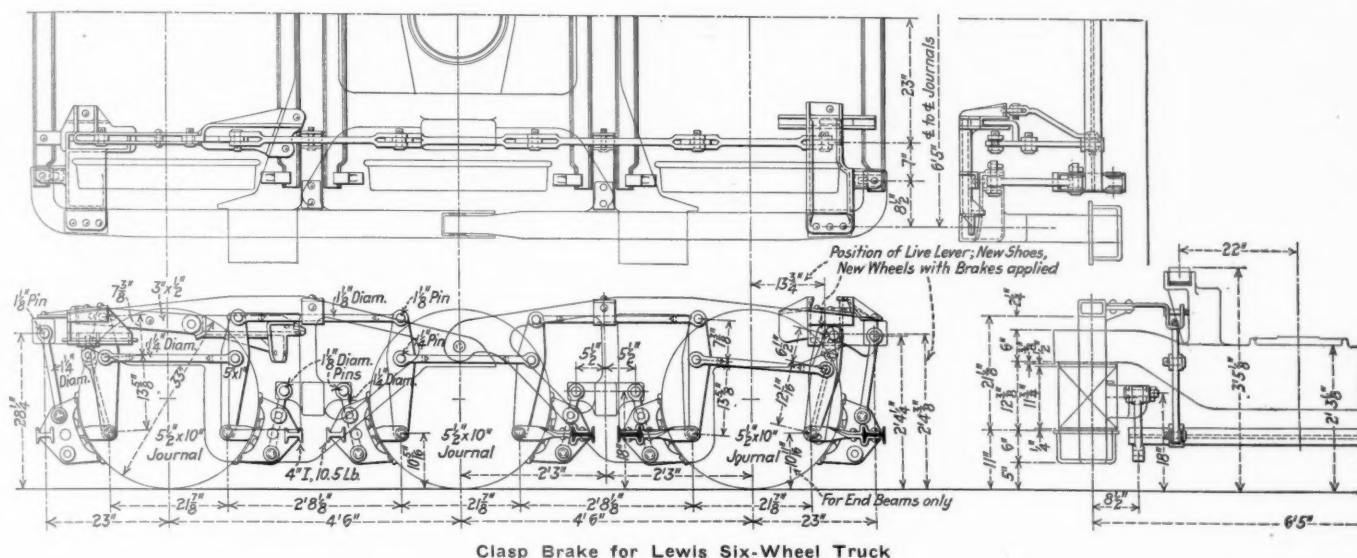


Plan, Side and End Elevations and Sections of Car Body—Chesapeake & Ohio 100-Ton Car

also a reinforcement in the center of the car on top of the floor plates consisting of a $\frac{1}{4}$ in. plate 20 in. wide and extending slightly beyond the door openings.

The body bolsters are of cast steel. They are in one piece, 30 in. deep, located inside of the car body and reaching from side to side of the car on top of the floor. The body center plates are of cast steel, 16 in. in diameter, and have

seven pressed steel braces, as will be noted from the illustration showing the side view of the car. The side sheets are set in at the ends to bring the grab irons inside of the outer face of the side sheets and are flanged over the end sheets. Reinforcing plates are provided at the ends of the body bolsters. The two sides are tied together by two crossbraces, one at each intermediate gusset brace. They are constructed



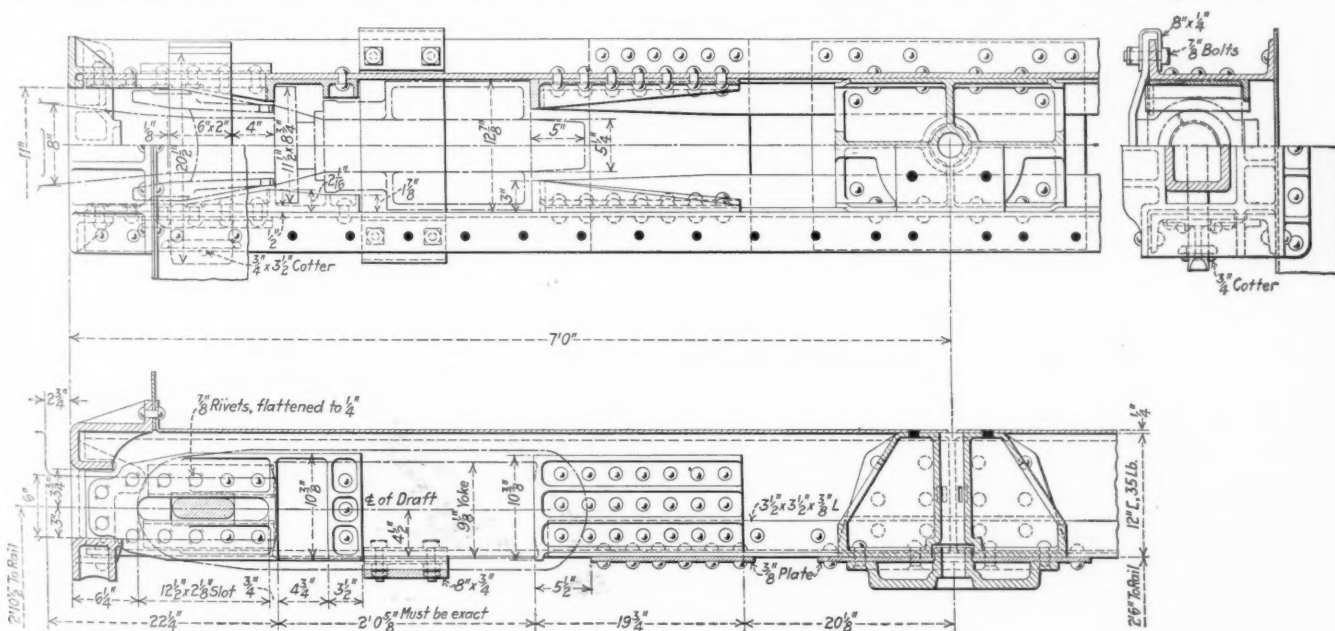
Clasp Brake for Lewis Six-Wheel Truck

machined bearing surfaces. The body bolster center braces are of cast steel machined and the center brace brackets are also of cast steel. The body side bearings are open-hearth steel bars, 4 in. by $\frac{5}{8}$ in. by 16 in., spaced 22 in. from the center of the car to the center of the side bearings, and with a clearance of $\frac{1}{4}$ in. between body and truck side bearings.

The side sheets, placed outside the side stakes as in the

of $\frac{1}{4}$ in. pressed plates, are of box shape and are shown clearly in the illustration of the inside of the car. Such braces were not used on the Norfolk & Western or on the Virginian cars, but should add materially to the stiffness of the sides.

The ends are of $\frac{1}{4}$ in. steel sheets, reinforced at the top by a 4 in. by $3\frac{1}{2}$ in. by $\frac{3}{8}$ in. bulb angle and by two



Draft Gear Arrangement

Virginian 120-ton cars to give the maximum width inside the body, are of $\frac{1}{4}$ in. steel pressed in toward the top and reinforced by a 4 in. by 4 in. by $\frac{7}{16}$ in. angle and at the bottom by a 4 in. by $3\frac{1}{2}$ in. by $\frac{3}{8}$ in. angle. Each side is also reinforced by nine $\frac{1}{4}$ in. pressed steel gusset side stakes located inside of the car. The sides are further stiffened on the outside at the top by four cast steel braces and by

pressed steel U-shaped horizontal stiffeners of 5/16 in. steel, 5 in. deep at the center.

There are three cross-bearers, one at the center of the car and the others intermediate between the center and body bolsters, consisting of $\frac{1}{4}$ in. pressed steel diaphragms with 8 in. by $\frac{1}{2}$ in. bottom tie plates, four crossies—two of pressed steel next to the center cross-bearers and two of 5 in.,

9.3 lb. bulb angles on top of the floor next to the body bolsters—and a diagonal brace to each corner of $\frac{1}{4}$ in. pressed steel riveted to the top of the floor. The floor is made of $\frac{1}{4}$ in. open-hearth steel sheets.

The large capacity coal cars used on the Norfolk & Western and on the Virginian are not provided with bottom doors, it being assumed that they would always be emptied by car dumpers. The Chesapeake & Ohio cars have flush bottoms but are equipped with emergency drop doors which can be used when necessary to unload the car at a point where car dumpers are not available. The four drop doors, each with an opening of 2 ft. 6 in. by 3 ft., are located as shown on the drawings. They are operated in two sets. Part of the cars are equipped with door operating mechanism designed by the Pressed Steel Car Company and part from the design of the Standard Steel Car Company.

The trucks are of the Lewis, six-wheel type with cast steel side frames and bolsters designed and furnished by the American Steel Foundries. The wheelbase is 9 ft. and the journals are $5\frac{1}{2}$ in. by 10 in., M.C.B. standard dimensions. The wheels are of wrought steel, part of them furnished by the Carnegie Steel Company and part by the Forged Steel Wheel Company. The side bearings consist of pockets cast integral with the truck bolster with cast steel filler blocks and three $\frac{3}{16}$ in. shims in each pocket for adjusting the side bearing clearance to the nominal amount of $\frac{1}{4}$ in. The journal boxes are of pressed steel, Kensington type, manu-

cheek has 27 $\frac{7}{8}$ -in. rivets; the front ones have 15 rivets. The draft sill tie is 8 in. by $\frac{3}{4}$ in. The couplers are A.R.A. type D with 6 in. by 8 in. shanks, connected by keys to cast steel yokes. The striking irons are of cast steel, the coupler carrier iron being cast integral with the striking casting.

In addition to the usual safety devices, the cars are provided with an inside ladder at each end.

The accompanying table gives the principal dimensions and other data of these cars and in addition similar information in regard to the large capacity coal cars used on the Norfolk & Western and on the Virginian.

Railroad	Chesapeake & Ohio	Norfolk & Western	Virginian
Capacity, stencilled..	182,000 lb.	200,000 lb.	218,000 lb.
Capacity, heaped 30 degrees	200,000 lb.	200,000 lb.	240,000 lb.
Cubic capacity level..	3,212 cu. ft.	3,122.5 cu. ft.	3,850 cu. ft.
C u b i c capacity, heaped 30 degrees.	3,703 cu. ft.	3,636 cu. ft.	4,450 cu. ft.
Estimated density of load	54 lb. per cu. ft.	55 lb. per cu. ft.	54 lb. per cu. ft.
Length over striking plates	44 ft. 7 $\frac{1}{2}$ in.	43 ft. 9 in.	50 ft. 8 $\frac{3}{4}$ in.
Coupled length.....	47 ft. 1 in.	46 ft. 2 in.	53 ft. 3 $\frac{1}{2}$ in.
Truck centers.....	30 ft. 7 $\frac{1}{2}$ in.	31 ft. 8 in.	36 ft. 10 $\frac{3}{4}$ in.
Truck wheelbase....	9 ft. 0 in.	8 ft. 6 in.	8 ft. 8 in.
Height, rail to top of car side.....	11 ft. 0 in.	11 ft. 0 in.	11 ft. 0 in.
Length, inside	43 ft. 3 in.	42 ft. 7 in.	49 ft. 6 in.
Width, inside.....	10 ft. 1 $\frac{1}{2}$ in.	9 ft. 6 in.	10 ft. 2 $\frac{3}{4}$ in.
Depth, inside, center.	7 ft. 5 $\frac{1}{2}$ in.	8 ft. 6 $\frac{1}{4}$ in.	8 ft. 5 $\frac{1}{2}$ in.
Depth inside, ends..	7 ft. 5 $\frac{1}{2}$ in.	7 ft. 5 $\frac{3}{4}$ in.	7 ft. 4 $\frac{1}{4}$ in.
Width outside, extreme	10 ft. 3 $\frac{3}{4}$ in.	10 ft. 1 $\frac{1}{4}$ in.	10 ft. 3 $\frac{1}{4}$ in.
Weight of car body.	34,900 lb.	29,020 lb.	43,200 lb.
Weight of two trucks	33,400 lb.	24,480 lb.	35,700 lb.
Weight of empty car.	68,300 lb.	53,500 lb.	78,900 lb.
Weight loaded.....	268,300 lb.	253,500 lb.	318,900 lb.
Per cent revenue load of total weight...	74.6 per cent	78.9 per cent	75.3 per cent
Rail load per axle, loaded car.....	44,717 lb.	42,250 lb.	53,100 lb.
Weight loaded per foot coupled length	5,695 lb.	5,490 lb.	5,985 lb.



Interior of Car Body, Showing Bolster, Gusset Side Stakes and Crossbraces

factured by the Union Spring & Manufacturing Company.

The cars are equipped with Westinghouse empty and load brakes, schedule KDE-4-10-16, having a 4-in. take-up cylinder, a 10-in. cylinder for use when the car is empty and an additional 16-in. cylinder for use when the car is loaded. The brakes are of the same type as those used on the Virginian as described in the *Railway Age* of June 17, 1921. Retaining valves are of the 10-20 lb. spring type.

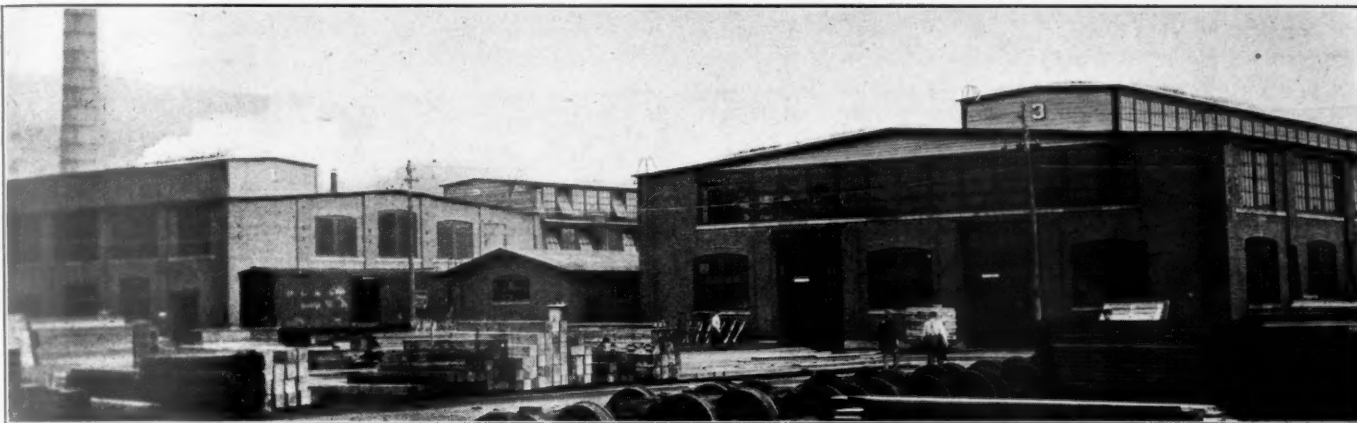
The brake rigging is designed to give a braking effort of 40 per cent on the empty car and also 40 per cent on the loaded car. The trucks are equipped with clasp brakes having vertical levers. The brake beams are of 4-in., 10 $\frac{1}{2}$ -lb. I-beams with two sets of open-hearth forged steel brake beam fulcrums spaced on 3 ft. 10 in. centers and substantial malleable iron brake heads. The hand brake is of the geared and multiplying type. The wheel load is 5,692 lb. on the empty car and 22,358 lb. on the loaded car. The nominal brake shoe pressures are 2,277 lb. on the empty car and 8,943 lb. on the loaded car.

The draft gear is of the Miner A-18-S friction type with 2 $\frac{3}{4}$ in. clearance between the coupler horn and the striking castings. The cheek castings are of cast steel; each rear

ADMIRERS OF HENRY FORD who believe that he can convert any weak railroad into a strong one seem at least to have the virtue of sincerity; a party of them have journeyed all the way from Arkansas to Michigan to see if they can get him to revive the Missouri & North Arkansas, a 300-mile road which numerous experts have found beyond their powers. The "committee," said to represent several towns, had to deal with Mr. Ford's secretary, the "wizard" himself being absent.



Austrian Munitions Factory Converted to Locomotive Shop



The Railroad Shop vs. the Contract Shop

Analysis and Comparison of Costs of Repairing 50 Similar Cars in Railway and in Contract Shops

THE relative cost of making heavy repairs to equipment in railroad shops and in outside contract shops has long been a matter of speculation. This subject has been discussed many times in the past and is a particularly live issue at the present moment. Much confusion has existed in making comparisons, due to the radically different cost accounting methods used in railroad and in contract shops. In order that comparisons may be of any real value similar things must be compared. As long as a common basis of measure is not used, attempts at comparisons must be always more or less futile. Unfortunately, railroad and industrial costs are not computed on a common basis. Railroad accounting methods are very effective in disguising many factors entering into cost accounting and, therefore, cannot be used for comparison with outside costs until certain additional elements are computed.

In a series of articles by J. W. Roberts, president of the Roberts-Pettijohn-Wood Corporation, Chicago, published in the *Railway Age*, an analysis and comparison is made between the cost of repairing 50 freight cars in the shops of one of the large trunk lines and similar repairs in a contract shop. This comparison brings out many important points frequently overlooked.

Railroad Accounting Methods

The accounting system used on railroads is prescribed by the Interstate Commerce Commission. Unfortunately this system resembles in no way cost accounting as practiced by industrial manufacturing plants or by other public utilities. The first cost found in railroading is considered the ultimate cost and many additional factors, known in commercial accounting as overhead, are not included. Railroad accounts are designed to furnish the cost of providing transportation and only incidentally the cost of maintaining equipment.

General accounts cover such main divisions as Maintenance of Way and Structures; Maintenance of Equipment; Traffic; Transportation—Rail; etc., but the demarcation between the Maintenance of Way and Structures and the Maintenance of Equipment accounts are in many places indistinct; likewise between these two general accounts and the Transportation—Rail, account. For example, the expense incident to hauling materials for use in maintaining the roadway and structures and for repairing and rebuilding equipment, etc., is not distributed between departments, but is charged to the Transportation—Rail, account; the maintenance

of shops and enginehouses even though the former are used in the maintenance of equipment, is charged to the account maintenance of way and structures; the expense of maintaining pile drivers, steam shovels and similar devices used in roadway maintenance is classified as maintenance of equipment. As another illustration, the expense entailed in hauling fuel used at shop power houses is not charged as a shop operating expense. Depreciation of buildings and tools is not fully accounted for. The overhead, being a general expense, is considered as common to all the activities of the railroad and is not separated for the different departments, such as the transportation department or the car department.

Investment in railroad shops, shop equipment, power plants, storehouses and service tracks is an appreciable one and frequently is subject to rapid deterioration. The cost of losses on these investments and the cost of providing money for improvements and taxes are all items properly chargeable against the railroad shop output, but are most difficult of ascertainment. Even the direct money outlay made in establishing railroad shop facilities is seldom known. In the case of a railroad, the expenses incurred in repairing cars in its own shops, other than the direct charges for productive labor and applied materials are usually so confused and so difficult of ascertainment that they are not recognized or are ignored. The repair of equipment being only an incidental affair in the operation of a large railroad system, there is an opportunity for other activities to carry and absorb many expenses which must be considered in commercial shop accounting.

A commercial shop is obliged to consider not only direct outlay for productive labor and applied materials, but likewise every other item of expense, however indirectly or remotely it may be involved. It must provide for expenses due to casualties or such other contingencies as sub-normal production. Provision must be made for taxes and a reasonable return from investments in fixed assets and working capital. Unlike a railroad, it usually has but one general source of revenue and a single outlet of expense and its selling price must provide for profits upon its raw material and their delivery. The necessity for careful management and economical performance is manifest as these affect the prices which must be charged for service. The cost to a railroad of having work done in outside shops consists of a known outside shop cost to which must be added the expense to the carrier

incidental to having the work done outside. The outside shop costs under normal conditions will include direct charges for labor and material and sufficient overhead for the use of property, working capital, enlargements, a margin for contingencies and what is commonly called profit.

Comparison of Railroad and Contract Shop Costs

A large railroad with excellent shop facilities having occasion to repair a large number of 60,000 lb. capacity wooden box cars, decided to overhaul part of them in its own shops and at the same time let a contract to a prominent car company, whose plant was situated on the carrier's line, for repairing a portion of the cars. This decision afforded an unusual opportunity for obtaining comparative costs.

The cars referred to were practically rebuilt. They received from three to six new sills; one or both new side plates and end plates; practically all new siding, decking, lining and roof sheathing, new doors, corner and end posts, Z-bar or Economy ends; "XLA" or Murphy roofs; Economy draft arms; two new side doors equipped with National door fixtures; Cardwell friction draft gear; heavier oak subsills; heavier needle beams, heavier U. S. Standard safety appliances and two coats of paint. The trucks were overhauled; wheels, springs and truck castings being renewed as found necessary; braces were placed on the arch bars to strengthen the truck in general and all brake attachments were repaired or renewed as required. When the work was completed, the rebuilt cars were practically as good as new cars of the same construction.

The railroad in question was above the average in physical condition of shops and equipment. The shops had been established only about five years and the equipment was comparatively new. The shop in question was devoted exclusively to heavy repairs and had been working for several months on similar repairs to the same line of cars.

For the sake of comparison, 50 cars were selected at the railroad shop and 50 cars in practically the same condition were selected at the contract shop. Unusual precautions were taken to obtain accurate costs for the two lots of cars. The accounting was done by outside men with the active co-operation and assistance of the railroad's officers.

Computing Total Cost of Work in Railroad Shop

The carrier does not accumulate in its record the cost pertaining to individual repair jobs, and it was therefore necessary to examine the details and build up the cost from the beginning. An enumeration of the various elements entering into the cost computation will show the method pursued and will also be suggestive in connection with similar work which may be done in the future at other points. In computing costs, the 50 cars were considered as a unit. The results given in this article, however, are for one car and were obtained by dividing each total item by 50.

APPLIED MATERIAL

A record was kept of the character of repairs made to the cars and the quantity of applied material was carefully developed in detail. Material reported used was checked against the work record and from the latter record a list of minor items not reported, which of necessity were used in the repairs, was compiled in conjunction with the local officers and car foreman. The different items were totaled and priced out from the storekeepers' and purchasing department records at prices f.o.b. carrier's rails at points of delivery.

HAULAGE OVER CARRIER'S LINE

The net weight of each item was computed, the distance hauled over carrier's line from point of delivery thereto to the shop where applied was ascertained and the net ton miles figured, and the cost of haulage calculated at the rate of seven mills per net ton miles.

Losses resulting from material spoiled in fabrication have been omitted; likewise losses due to shortages in shipments, breakages in handling and like causes were not included. Neither was anything included for inventory adjustments.

SALVAGED MATERIAL AND SCRAP

Credit was given for recovered material salvaged from the repaired cars at the rate of 75 per cent of the current cost of new usable material and at current prices for scrap. The cost of handling is not deducted in this connection as the expense was included in overhead accounts and distributed as such.

DIRECT LABOR

Carpenter labor was taken directly from the service records.

Record cards were turned in by the workmen which showed the individual car worked on each day and the time devoted to each operation on each car. The total time reported was checked against the payrolls. Service cards were not required of the other classes of men, however, and it was necessary to use an average cost per car for these respective classes of labor. Certain work, such as riveting coupler yokes, rectifying body bolsters, and reclamation shop recovering 16 journal boxes and four-column bolts, was done in other departments which did not record the time devoted thereto. The cost of these items was determined from a performance time study and the application of the standard rate of pay.

INDIRECT SHOP LABOR

Indirect labor in each department each month has been apportioned on a basis of the departmental direct labor. For instance, mill foremen and mill men have been distributed on the basis of carpenter labor, and assistant general foremen, clerks and watchmen on the total labor to which each expense was common.

SHOP EXPENSE

The total shop expense for labor, operating materials and supplies, fuel, electric current consumed and ice was found for four months during which the work was under way. This was then pro-rated against the test cars. These charges include nothing for haulage of the fuel used over the rails of the company. The tonnage of fuel used was ascertained, likewise the distance hauled over the carrier's line from the normal sources of supply, and haulage costs were computed at the rate of seven miles per net ton mile. The cost of transporting material and supplies is necessarily omitted because of inaccessibility of the data as to weight and point of origin. Shop expense was apportioned on the basis of assigned shop labor.

INSURANCE

Premiums paid on commercial policies for fire insurance and allowances on the carrier's own insurance fund to protect the margin between the insurance carried and the amount of hazard on the insured facilities comprising the shop layout, was reduced to a monthly basis and distributed on the basis of assigned shop labor.

MAINTENANCE OF MACHINERY AND TOOLS

The total expense charged to accounts 302—Shop Machinery, 304—Power House Machinery, and 335—Other Expenses, representing the total expenditures during the test period at the shop in question, was apportioned on the basis of assigned shop labor. The records did not lend themselves to analysis in such a way as to permit of averaging the machinery maintenance expense for a longer period which apparently would have increased the charges somewhat.

MAINTENANCE OF BUILDINGS AND TRACK

The labor and material charged during the year 1920 against the maintenance of the buildings and track compris-

ing the shop facilities was taken as the basis for ascertaining the cost of maintenance of these facilities. The total charges were reduced to a four months' average and this amount apportioned on the basis of assigned shop labor. In the charges thus distributed, nothing was included for transporting the materials used over the carrier's line, which could not be computed because of lack of detail as to material quantities. The records were not kept in such detail as to show the facilities to which repairs were made and repair expenses not described may have applied to the facilities in question. Cognizance was taken only of the charges identified to the facilities involved.

MAINTENANCE OF BUILDINGS USED IN COMMON

Other shops than the one in which the test cars were repaired are located at the same point and during the year 1920 account 235—Shops and Enginehouses received charges common to all such shops. Charges for the period were reduced to a four months' average and then distributed on the basis of assigned shop labor (less superintendence) in all shops.

DIVISIONAL OVERHEAD, MAINTENANCE OF WAY AND STRUCTURES

Divisional charges, accounts 269—Roadway Machines, 271—Small Tools and Supplies, 274—Injuries to Persons, 276—Stationery and Printing, 277—Other Expenses, exclusive of accounts benefited thereby as, for instance, account 275—Insurance, were apportioned in a similar manner.

ENTIRE LINE OVERHEAD, MAINTENANCE OF EQUIPMENT

Superintendence and other overhead expenses, accounts 201—Superintendence, 332—Injuries to Persons, 334—Stationery and Printing, were ascertained and their relationship between total overhead expense and the total expense supervised was found and on the basis of this relationship the supervised expenses were assigned against the test cars.

It should be mentioned that divisional overhead expense relating to maintenance of equipment was consolidated with system charges by the carrier and could not be segregated and separately accounted for. The consolidation of the expense before apportioned reduces the proportion which would otherwise be assignable to the work in question.

ENTIRE LINE OVERHEAD, MAINTENANCE OF WAY AND STRUCTURES

The charge against the test cars for system overhead applicable to all maintenance of way and structures accounts, which is represented by charges to account 201—Superintendence, was predicated upon the equitable distribution of the total charges to this account on the basis of the total expenses supervised, using the experience of the calendar year 1920.

ENTIRE LINE OVERHEAD, REPAIRS TO OFFICES AND STOREHOUSES

The identifiable expenditures for repairs to system general offices and general storehouse buildings and appurtenances during the year 1920 were collected and their relation to total operating expenses (less common to system repairs) and expenditures for additions and betterments were found and on the basis of this relationship, the cost assigned to the test cars was surcharged pro rata.

SYSTEM GENERAL EXPENSES

System general expenses for the year 1920, comprising items included in the various primary accounts under the subdivision "General" were found to be equivalent to 3.473 per cent of the total expenditures for other operating expenses plus the expenditure for additions and betterments to road and equipment, excluding the adjusting credit of the property retired and the amount of liability for certain equipment

allocated by a government order which involved no general expense during this period on the part of the carrier's organization.

DEPRECIATION ON SHOP BUILDINGS, TOOLS AND MACHINERY

The railroad's policy does not provide for a maintenance fund for perpetuating the life of such property, although deterioration not offset by current repairs does accrue. Depreciation was therefore computed upon buildings and depreciable machinery used in the repair of cars on the basis of the original cost for each item. Cognizance was taken of the character of each item and depreciation was based upon experience as to the life expected of such property. The rates used were taken from a table promulgated by the U.S.R.A. for the use of car builders computing the cost of work performed on a cost plus contract and which was subsequently adopted for use by many builders.

It was impossible to ascertain the amount of taxes and other fixed charges which should be borne by the property and equipment devoted to car repairs. During the year 1920, for each one dollar distributed as operating expenses as designated by the Interstate Commerce Commission's classification, the carrier had a further outgo for fixed charges which include taxes, uncollected revenues, operating losses, etc., of 20.081 cents. Because of the lack of a more equitable basis for disposing of this element of cost, it was assigned to the test cars on a pro rata basis. This may not be strictly accurate, but it has nevertheless done substantial justice to the situation in arriving at a comparable cost.

Basis of the Contract for Outside Repairs

Under the terms of the contract, the work done in the outside shop was to be charged for on the following basis:

(a) Direct labor to be based on the carrier's piece work schedules which were in effect July 1, 1917, plus 10 per cent, plus 30 per cent (the equivalent of 43 per cent) to equate such rates to the basis of the current wage schedule.

(b) For handling materials, a charge of \$6 per car.

(c) For milling lumber, a charge of \$8 per thousand board feet.

(d) For blacksmith work, agreed prices per operation.

(e) The aggregate of the foregoing items to be surcharged 100 per cent for overhead expense.

(f) Materials to be furnished in part by the carrier and to that extent exempted from the surcharge for profit; in part to be furnished at reciprocal prices (i. e., furnished by the carrier and billed at agreed prices and rebilled by the contractor at the same prices) and subject to the surcharge for profit, and in part to be furnished by the contractor at agreed prices, subject to the surcharge for profit.

(g) To the sum of the foregoing items to which applicable, profit to be added on a graduated scale, regulated by the amount of charge per car, the average rate of profit surcharged being between 10 per cent and 11 per cent.

The amounts billed the carrier under the terms of the contract do not, of course, represent the sole cost to it of the work done by the contractor. Among the possible incidental expenses may be mentioned:

(a) The cost to it of free materials furnished the contractor, and not included in his bill.

(b) The cost of delivering such materials, and attendant store expenses, etc.

(c) Moving the cars to be repaired to the contract shop, and returning them, to the extent that such movement represent otherwise useless haulage.

(d) Concentrating recovered scrap.

(e) Inspection of work, and reviewing accounts at the contract shop.

(f) Unoccupied space in its own shops and attendant expense, idle investment, etc.

(g) Administrative, purchasing and accounting expense.

These, and other kindred items have received careful attention, and to the extent that such expenses were experienced, have been added to the amounts billed by the contractor in arriving at the total cost of the outside shop work.

Compiling Cost of Work in Contract Shop

APPLIED MATERIAL

This includes all material supplied by the builder for which bills were rendered and also certain so-called "free" material furnished by the railroad to the contractor, and delivered at the contractor's works. This material consisted of car roofs, draft arms, door fixtures, draft gear, and steel car ends, the value of which was ascertained from the purchase records. The cost of hauling the material over the carrier's own line and delivery at the car plant was computed at seven mills per net ton mile. Aside from the small amount of material furnished from the general storehouse to accommodate immediate needs, this material was moved direct in car load lots and was not subject to storehouse accounting. The cost of purchasing and accounting for it is included in general expense apportioned to the contract cars, the same as company repaired cars.

CREDIT FOR SALVAGED MATERIAL AND SCRAP

The contract covered the basis on which scrap and useful material recovered would be accounted for. Recovered material, valued at 75 per cent of the cost new, amounted to \$81.30 per car. In addition there was recovered an average of 892 lb. of miscellaneous scrap per car at \$15 per ton, or \$6.69 per car. From the total salvage per car is deductible the cost of handling as charged under the contract, plus 10 per cent for profit, or \$2.20 per car. The net weight of the usable material and scrap was used as a basis for computing the cost of hauling by the carrier at seven mills per net ton mile from the contract plant to the usual point of scrap concentration. The cost of unloading the concentrated scrap and useful material is included in the carrier's storehouse expense in which the materials handled for both shops have been caused to participate on an equitable basis.

DIRECT LABOR

All direct labor, including that for handling materials, milling lumber and blacksmith work, was billed as per contract.

OVERHEAD EXPENSES

This includes the contractor's overhead at 100 per cent of the direct labor provided for in the contract and also a contractor's profit as provided for in the contract.

Additional incidental expenses borne by the carrier include switching cars to and from the plant of the contractor equivalent to seven dollars per car. To this is added an item covering the system general expense as it is considered that the railroad's general expenses representing administrative and supervisory expenses, purchasing, accounting and similar items of a general character, are applicable to the cost attached to the outside contract.

The cars repaired at the contract shop, which is located at an intermediate point on the carrier's system, were not given any special movement to make them applicable for repairs. The cars were selected from those moving through or made empty at the terminal at which the repair plant is located. The only expense involved was the switching to and from the plant. The same practice was followed at the railroad's shop. In both cases, also, the points being tonnage producing stations, as cars were repaired and released they were simply contributed to the local supply ready for loading and special movements to loading points were unnecessary.

The carriers provided car inspectors and accountants at the contract shop to pass on the quality of work and to verify the charges of the contractor. The cost of this in-

spection and accounting was found to be approximately \$16.00 per car. This expense, however, was charged to the overhead account from which a pro rata share was charged to the test car. For this reason the charge of \$16.00 per car was not included in the cost.

FIXED CHARGES

It has been previously shown that the ratio of fixed charges to the carrier's expenditure for operating expenses, additions and betterments, for the year 1920 was 20.081 cents per dollar of expenditure. As the letting of certain work to outside shops did not result in idle investment it is not clear to what extent, if any, the cost dependent upon the contract work should be increased because of interest, taxes, operating losses, etc., which are incident to the carrier's operation. It might not be fair to say that no portion of this amount should be included as a part of the cost in question, but it is quite obvious that under the circumstances it would be unfair to say that the entire amount should be considered as a part of such cost. If this were done, the comparison would be on the basis substantially that the railroad shops were in disuse. It seems best, therefore, to leave this question to the judgment of the reader.

Summary and Comparisons

It is most difficult, as has already been stated, to obtain a true comparison in an instance of this kind. However, the summaries given in Table 1 and Table 2 are as complete and fair as possible to both shops.

TABLE 1—ANALYSIS OF THE COST OF WORK IN RAILROAD SHOPS

Applied materials:	
Applied materials, prime cost.....	\$903.18
Haulage over carrier's line.....	29.63
Less net value salvaged material and scrap.....	—87.99
Net cost of material.....	844.81
Direct labor:	
Carpenters.....	\$232.72
Steel workers.....	8.52
Blacksmiths.....	7.30
Air brake men.....	5.60
Painters.....	4.80
Door makers.....	2.80
Mounting car wheels.....	1.62
Miscellaneous.....	3.71
Total cost of direct labor.....	\$267.07
Overhead expenses:	
Indirect shop labor.....	\$87.91
Shop expense (labor, material, power, etc.).....	47.67
Insurance on buildings and machinery.....	0.26
Maintenance of machinery and tools, direct charge.....	26.34
Maintenance of buildings and tracks, direct charge.....	4.72
Maintenance of buildings used in common.....	1.16
Divisional overhead maintenance of way and structures.....	0.13
Line overhead maintenance of equipment.....	34.40
Line overhead maintenance of way and structures.....	0.30
Line overhead repairs, offices and storehouses.....	0.05
System general expenses.....	48.72
Depreciation on shop buildings, tools and machinery.....	6.65
Total operating overhead.....	\$258.31
Total cost exclusive of fixed charges.....	\$1,370.19
Fixed charges for interest, taxes, etc.....	292.82
Total average cost per car.....	1,663.01

TABLE 2—ANALYSIS OF THE COST OF CONTRACT WORK

Applied materials:	
Applied materials, billed.....	\$544.39
"Free" materials at cost to carrier.....	360.34
Haulage over carrier's line.....	7.74
Less net value salvaged material and scrap.....	—83.21
Net cost of material.....	\$829.26
Direct labor:	
Labor on equated piecework base, billed.....	\$131.81
Handling materials, billed.....	6.00
Milling lumber, billed.....	15.35
Blacksmith work, billed.....	8.56
Total cost of direct labor, billed.....	\$161.72
Overhead expenses:	
Contractor's overhead, billed.....	\$161.72
Contractor's profit, billed.....	89.88
Cost of switching.....	7.00
System general expense.....	46.29
Total overhead and profit.....	\$304.89
Total cost to carrier, exclusive of its fixed charges.....	\$1,295.87
Apportionment of fixed charges on same basis as applied to carrier's cost of work done in its own shops.....	276.93
Total cost to carrier if above fixed charges were included.....	\$1,572.80

In connection with the analysis of the cost of the work in the railroad shop, attention should be drawn to the fact

that of the costs pertaining to the work done, only direct labor, shop expense and applied material costs to the extent of \$1,297.47 were identified in connection with the carrier's accounts. The remainder, \$365.54 was charged to other accounts or not included at all. In other words, of the total costs to the carrier as developed, 78 per cent could be identi-

DIVISION OF TOTAL COST OF OUTSIDE WORK

	Paid to contractor	Additional railroad costs
Applied materials, etc.....	\$544.39	\$368.08
Less salvage credit.....		-83.21
Direct labor	161.72	.....
Overhead	161.72	53.29
Profit	89.88	.....
Total, exclusive of fixed charges.....	\$957.71	\$338.16
Fixed charges, if included.....		276.93

fied and recognized if the accounts were analyzed, while 22 per cent was either omitted from the accounts entirely or so disguised as to appear unrelated to the expense of repairing cars.

An examination of the analysis of the cost of the contract work shows that only part of the expense was an actual payment under the contract, the balance being for material and overhead borne by the railroad and not covered by any direct bills. The accompanying summary shows the division of costs.

A comparison of the analysis tables for the two shops shows a comparatively small difference in the costs of materials and a considerable difference in the item for labor. There is an apparently higher allowance for overhead in the contract shop, but no conclusions can be drawn as the methods used for arriving at the overhead were radically different in the two shops. As has already been pointed out, the inclusion of a sum for fixed charges in connection with the work done at the contract shop is debatable.

If fixed charges are not added to the cost of the contract work, the average cost per car is \$1,295.87 against \$1,663.01 in the railroad shop, a saving of \$437.14 or 22 per cent of the railroad shop cost. If the full fixed charges are added to the cost of the contract work, it becomes \$1,572.80, or \$90.11 less than the cost in the railroad shop, which represents a saving of about 5½ per cent.

Bad Order Cars Reached Maximum in August

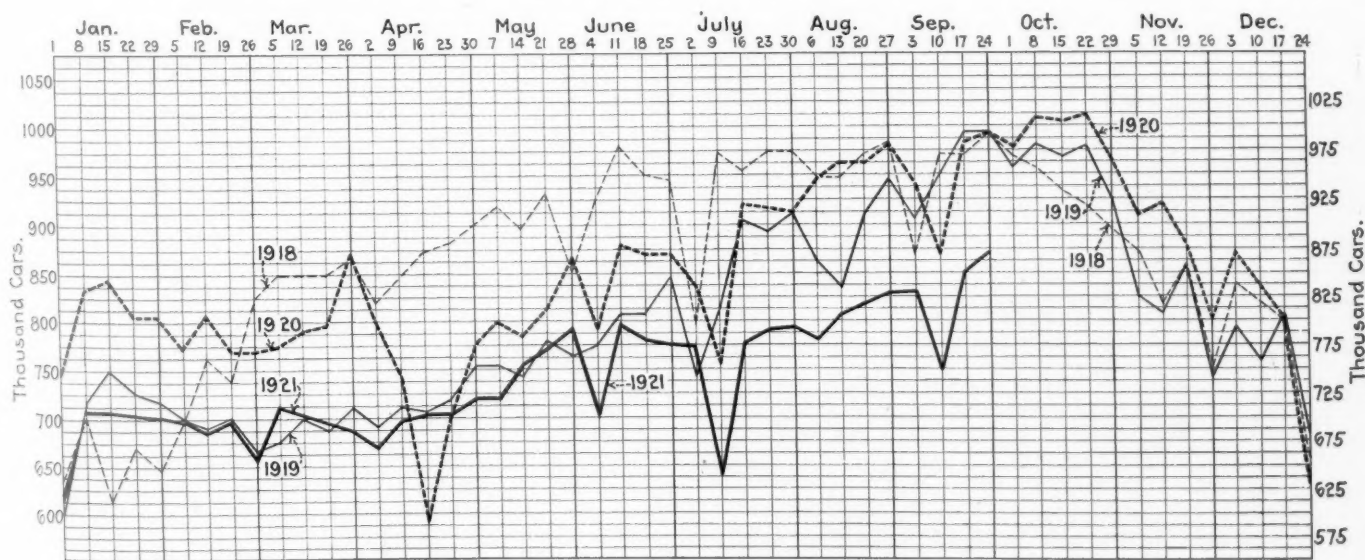
Analysis of Present Situation and Its Bearing on the Problem of Freight Car Repairs

THE first decrease in the number of bad order cars that has occurred this year took place in the last half of August. The reduction was slight, from 16.6 to 16.2 per cent, but it is significant as indicating that the railroads have at last begun to repair cars faster than they are made bad order. A survey of the present situation will show how great a task it will be to get the number of bad orders down to a normal figure.

On January 1, 1921, there were 191,234 bad order cars

tures for car maintenance. Later the roads were looking forward to a reduction in wages and so were led to postpone repair work still longer. On July 1, when the new wage rates became effective, the unserviceable cars amounted to 354,611, or 15.4 per cent. Even though many shops were reopened on July 1, little progress was made in stopping the increase of bad orders which rose to 382,440, or 16.6 per cent on August 15.

As already noted, the number of cars in need of repairs



Fluctuation in Freight Traffic from 1918 to Date, as Shown by Weekly Revenue Car Loading

reported which amounted to 8.5 per cent of the total number of freight cars on line. This is over twice the normal percentage and ordinarily would have resulted in an intensive campaign to improve car conditions. At that time, however, the roads were in a very serious financial condition. In fact, during the months of January and February, most of them operated at a loss, so it was not possible to increase expendi-

was brought down on September 1. The figures for September 15, however, show that during the next two weeks the bad orders remained practically stationary.

Freight Traffic 76 Per Cent of 1920

The railroads would be unable to operate with such a large number of bad order cars if business was normal. If

traffic should increase rapidly, the large amount of unserviceable equipment would prove a serious handicap. Business during the early part of the year has been far below normal but the number of freight cars loaded weekly is now increasing at a fairly steady rate as is evident from the chart showing the revenue car loadings for the past four years. Comparison of the loadings for 1921 with previous years is confusing because of the abnormal conditions which have influenced loading in the period included on the chart. The early months of 1919 represented a rather severe depression while the latter part of 1919 and the first 10 months of 1920 was the busiest period the railroads have ever experienced. It is evident that a steady improvement is taking place in the car loadings, but the increase is little more than has occurred in previous years and seems to be due largely to the seasonal fluctuation in the amounts of traffic to be handled, rather than to any distinct improvement in business.

Car loadings are a rather unsatisfactory basis for comparison of traffic because of the variations in the amounts loaded in each car. For instance in the first seven months of 1920 the average net tons per loaded car was 28.6, but during the first seven months of 1921 it fell to 27.9. The ton mile movement is a more satisfactory basis of comparison, but unfortunately these figures are not available as promptly as the reports of car loadings. The ton miles of freight moved in the first seven months of the present year was 76.5 per cent of that moved in the corresponding period of 1920, while the car loadings were 89 per cent of the 1920 figure. The last figure for the weekly car loadings available for this year is 89 per cent of the corresponding week in 1920, which is no higher than the ratio that has existed throughout the year.

Will Traffic Increase or Decrease?

It is impossible to forecast what may take place during the last months of the year. Ordinarily there is a sharp decrease in traffic commencing about the last week in October and continuing until the end of the year. There are apparently no unusual conditions that would change the tendency very decidedly, although the resumption in the iron and steel indus-

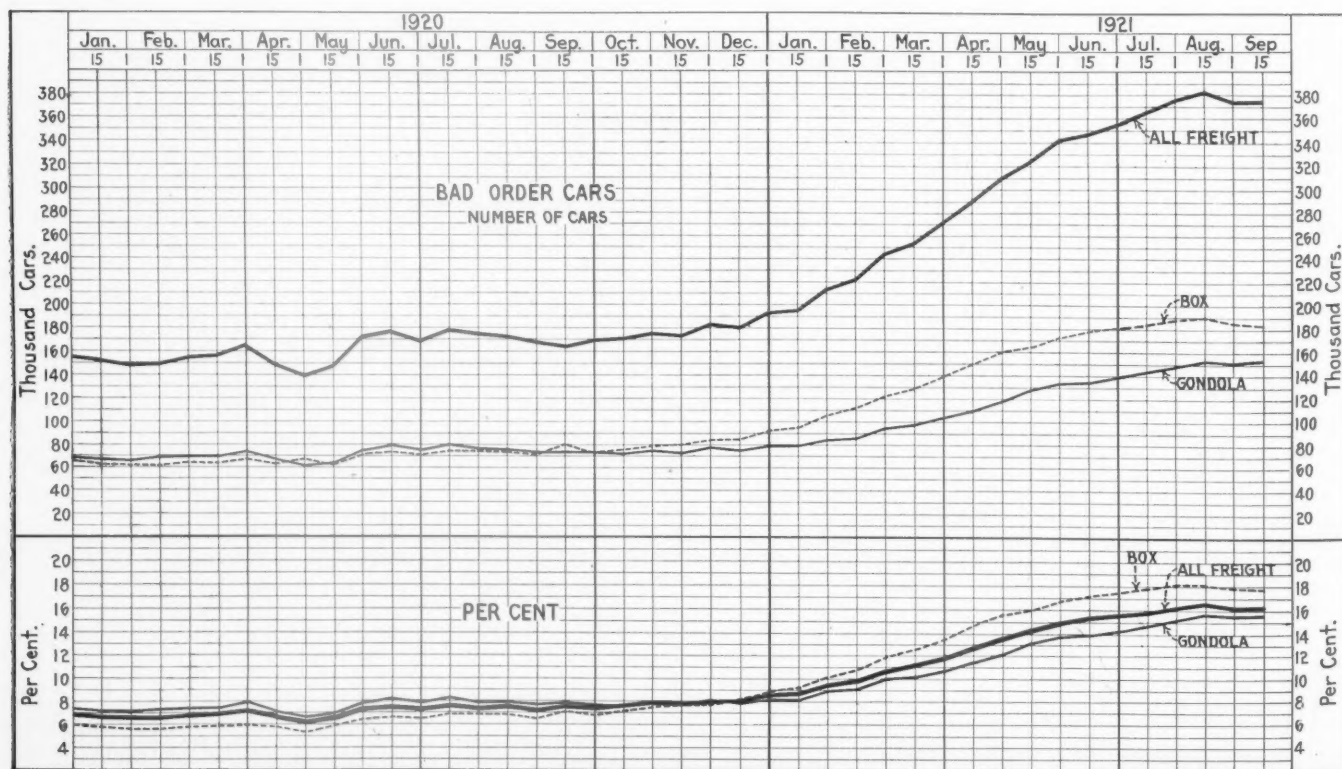
try, which is an important source of tonnage, may cause the decrease to be less rapid than in previous years.

On account of the very light traffic there has been a surplus of cars throughout the year even in spite of the large number

STATISTICS OF CAR SUPPLY, TRAFFIC AND TIME PER TRIP, 1920 AND 1921

Date	Cars on line	Bad order cars	Surplus	Net in revenue service 1—(2+3)	Weekly car loadings nearest to 1st or 15th	Weeks per Trip (4÷5)
1920						
Jan. 1.....	2,263,541	153,995	.....	2,109,546	744,969	2.83
15.....	2,260,266	151,196	.....	2,109,070	865,992	2.44
Feb. 1.....	2,290,807	147,999	.....	2,142,808	780,455	2.75
15.....	2,289,618	149,593	.....	2,140,025	868,673	2.47
March 1.....	2,307,060	153,727	.....	2,153,333	774,297	2.78
15.....	2,278,066	155,107	.....	2,122,959	796,566	2.67
April 1.....	2,309,449	164,660	.....	2,144,789	801,588	2.68
15.....	2,280,207	149,568	.....	2,130,639	584,089	3.65
May 1.....	2,299,124	139,786	.....	2,159,338	772,908	2.79
15.....	2,263,115	146,979	.....	2,116,136	784,044	2.70
June 1.....	2,356,652	170,493	.....	2,186,159	768,974	2.85
15.....	2,335,299	175,258	.....	2,160,041	869,142	2.49
July 1.....	2,344,359	168,589	.....	2,175,770	839,629	2.59
15.....	2,330,780	176,672	.....	2,154,108	923,968	2.33
Aug. 1.....	2,344,812	174,371	.....	2,170,441	914,128	2.37
15.....	2,298,581	171,773	.....	2,126,808	962,352	2.21
Sept. 1.....	2,298,295	166,146	.....	2,132,147	947,743	2.25
15.....	2,176,532	163,710	.....	2,012,822	983,913	2.05
Oct. 1.....	2,278,273	167,965	.....	2,110,308	975,946	2.16
15.....	2,264,258	168,888	.....	2,095,370	1,005,563	2.09
Nov. 1.....	2,273,792	174,276	.....	2,099,516	973,120	2.16
15.....	2,267,047	174,189	.....	2,092,858	880,528	2.37
Dec. 1.....	2,279,573	182,097	30,022	2,067,454	872,162	2.37
15.....	2,246,512	179,445	91,472	2,075,595	795,858	2.60
1921						
Jan. 1.....	2,251,173	191,234	193,925	1,866,014	598,905	3.12
15.....	2,252,432	194,113	286,462	1,771,857	709,888	2.50
Feb. 1.....	2,265,502	213,180	323,376	1,729,046	699,936	2.47
15.....	2,267,238	220,420	392,162	1,644,656	681,627	2.42
Mar. 1.....	2,273,033	243,586	412,800	1,616,657	658,222	2.46
15.....	2,268,585	252,824	423,815	1,591,946	702,068	2.27
Apr. 1.....	2,281,986	270,319	495,781	1,515,886	666,642	2.28
15.....	2,275,484	289,771	499,248	1,486,465	703,896	2.12
May 1.....	2,289,282	309,971	482,076	1,497,235	721,997	2.07
15.....	2,288,242	324,969	450,164	1,513,109	750,158	2.02
June 1.....	2,301,749	341,337	393,701	1,566,711	787,237	1.98
15.....	2,302,724	346,861	381,526	1,574,337	780,741	2.02
July 1.....	2,300,155	354,611	373,128	1,572,416	774,808	2.03
15.....	2,295,660	365,092	370,787	1,559,781	776,252	2.01
Aug. 1.....	2,302,304	376,417	327,876	1,604,011	796,570	2.02
15.....	2,300,929	382,440	282,213	1,636,276	808,965	2.02
Sept. 1.....	2,303,669	374,087	246,001	1,683,581	830,601	2.03
15.....	2,298,383	374,431	219,267	1,704,685	853,762	2.00

of cars that were on the bad order tracks. During recent months, however, the surplus has been decreasing rapidly. The maximum surplus reported was on April 8 when the



Bad Order Cars as Reported Semi-Monthly, January 1, 1920, to September 15, 1921

excess of idle cars over unfilled orders for cars amounted to 507,274; on September 8 this had decreased to 219,267. Over one-half of surplus, or about 118,000 cars were coal carrying cars. Although the railroads have more box cars than coal cars, the surplus of box cars was only 62,000.

Efficiency of Operation Affects Demand for Cars

The demand for cars varies not only with the traffic, but also with the performance that is made by each individual car, as measured by the ton miles of traffic handled over a

traffic for the back haul on certain classes of cars, or the necessity for returning cars empty to the home line. During the entire year 1921, the empty car movement has been abnormally heavy chiefly because of the effort that has been made to get cars back to the home road in order that they might be overhauled. During January, the empty mileage was 42.5 per cent of the total. In other words, instead of an empty movement of approximately 43 per cent of the loaded movement as occurs under normal conditions, the empty mileage was 75 per cent of the loaded mileage. During the latter months the ratio decreased but even in July 36.7 per cent of the total movement was empty car miles.

The miles per car per day varies considerably with the fluctuation in traffic, being high when all the cars are in use and falling when large numbers are standing idle on side tracks. It is also affected to some extent by congestion and delays due to the condition of the weather or other causes. During the past five years the figure has varied from 29.0 to 19.4 miles per day. During the heavy traffic of last fall, it was about 28 miles although efforts were made to increase it to 30 miles per day. Since business has fallen off, the daily car movement has decreased considerably and in July was only 21.6 miles. This seems to indicate a serious falling off in the efficiency of utilization of cars, particularly when considered in connection with the abnormally high ratio of empty mileage to total mileage.

The third factor influencing the amount of tonnage handled per car is the average load. During 1918 and 1920 when special efforts were made to increase loadings, an average of slightly over 30 tons per car was obtained. Since the first of the year the average load has decreased and now stands at about 28 tons. Normally there is less fluctuation in this figure than in the miles per day, the minimum value for any month in the last five years being 25.6 tons. The present performance is fairly creditable considering the great reduction in the tonnage of coal, ore and other bulk products being moved.

Car Performance Affected by Surplus and Bad Orders

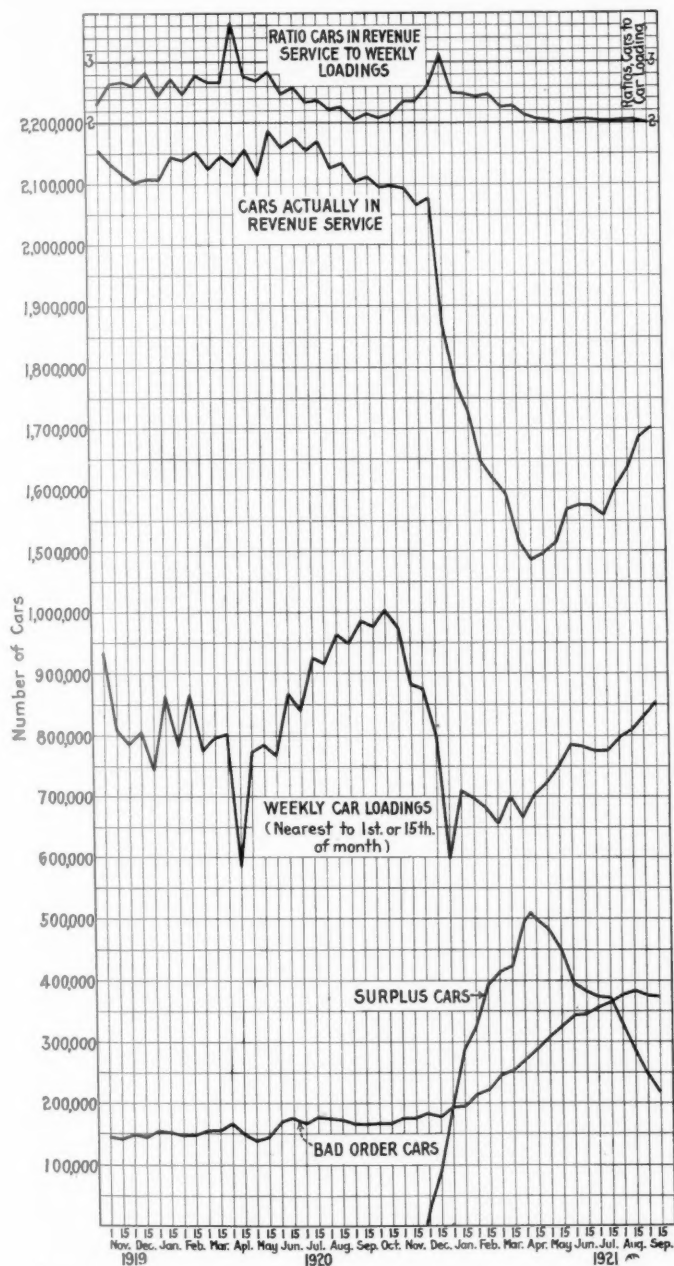
If the standards of car performance are set at 30 per cent empty car mileage, 30 miles per car per day and 30 tons per car, neglecting the effect of bad order and surplus cars, each car should produce 630 ton miles per day. In the seven months ending July 31, 1921, the net ton miles per car day were only 375 as compared with 472 in 1920. For the month of July the figure was 376 as compared with 526 in 1920.

In analyzing the performance of cars at the present time, it should be borne in mind that the statistics are based on the total number of cars on line. Thus the miles per car per day and the ton miles per car per day made by the cars actually in service are considerably greater than given above because of the large number of cars bad order or standing idle. Thus the statistics for July show that out of 2,440,792 cars on line, there were 375,769 bad order and 370,000 additional surplus of idle cars.

Deducting the bad orders and surplus cars from the total on line, it is found that only 1,694,000 cars or 69.5 per cent of the total were actually in use moving the traffic. These cars that were being moved were moving 31.1 miles daily and producing 541 ton miles per day. Comparing this with the average value for 1920 it is evident that excellent performance is being obtained from the cars that are actually in service and the unfavorable average is due solely to the large percentage of equipment that is idle.

Quick Movement Reduces Number of Cars Required

Another interesting measure of the rate at which cars are being moved is afforded by a comparison of the cars in service with the number loaded weekly. This gives approximately the number of weeks required for a complete trip and is plotted on one of the charts, from November, 1919, to date.



Variations in Car Conditions and Performance During the Past Two Years

given period. There are numerous factors entering into this statement and in order to get a clear conception of the conditions, it is advisable to analyze each factor separately. The three factors that directly influence car performance are: first, the percentage of loaded mileage to total mileage; second, the miles moved per day per car, and third, the average net revenue load per car.

Normally about 70 per cent of car mileage is loaded mileage and 30 per cent is empty movement caused by lack of

By referring to the chart it will be noted that the time per trip is roughly an index of the amount of traffic handled. The normal time is about two and one-half weeks, but during the heavy traffic of 1920 it decreased to slightly over two weeks. During this period the number of cars in service remained nearly constant. While weekly car loadings fell from 1,000,000 to 600,000, the time per trip increased to three weeks.

Commencing about December 1, 1920, there was a large increase in surplus and bad order cars. The result was to upset the relation between the volume of traffic and time per trip. From December to April, while there was little increase in traffic, the time per trip was gradually reduced to about two weeks. Since that time the number of cars in actual service has increased practically in proportion to the car loading and the time per trip has remained constant. Thus during the present period of light traffic cars are being turned with a rapidity that is ordinarily attained only under the stress of heavy traffic. This does not mean that trains are moving faster, for even while in service the average freight car is moving only about three hours per day. The decreased time results from more prompt dispatching in yards and quicker loading and unloading.

The principal significance of the present rapid movement is in relation to the future supply of cars. It will be noted from the chart that the car surplus has been decreasing rapidly. Between April 7 and September 15 it fell from 507,000 to 219,000. The reduction has been due solely to the increase in traffic, the time per trip remaining practically constant. At the present rate of decrease, the surplus would disappear entirely in a little over two months.

As has already been pointed out there may be a slackening in business at the end of the year, but other influences are likely to bring about a reduction in the car surplus. During cold weather there are always delays to trains and often serious congestion occurs at terminals and the time per trip is almost certain to increase. If only one extra day was needed to complete each trip, it would require 112,000 additional cars to handle the same amount of freight business. Thus an increase of two days in the time per trip would more than wipe out the existing surplus.

It may seem strange that the railroads have been able to handle traffic about 76 per cent as great as last year with only 69 per cent of the equipment actually in use. The explanation is to be found in the quick turning of the equipment. The figures make it clear that the existing surplus may be wiped out in a very short time. If a large increase in business should occur, the resulting congestion of facilities would slow down the movement and a serious shortage would be the natural result. Of course the revival of business may be quite slow, but past experience has shown that the most experienced railroad officers are often unable to foresee the trend of events and there is an element of danger in the present situation that makes it advisable to get the cars in condition as rapidly as possible in order to avoid a shortage later on.

Cost of Repairing Equipment

The present bad order situation is so extremely bad, it is safe to say that it presents a greater problem than the car department has ever faced before. Last year the railway executives set as a goal the reduction of the bad order cars to four per cent. The present figure is 16.3 per cent. Instead of 374,000 bad order cars, there should be only about 98,000. Some idea of the task involved in getting bad orders back to normal can be gained from the expense involved. As the basis for an estimate, it may be assumed that the bad orders will be reduced to four per cent by repairing all the light repair cars and all but 98,000 of the heavy bad orders. This will involve light repairs to 83,000 cars and heavy repairs to 193,000 cars. The light repairs are of minor importance and will be disregarded. The amount of work required on the heavy bad orders varies

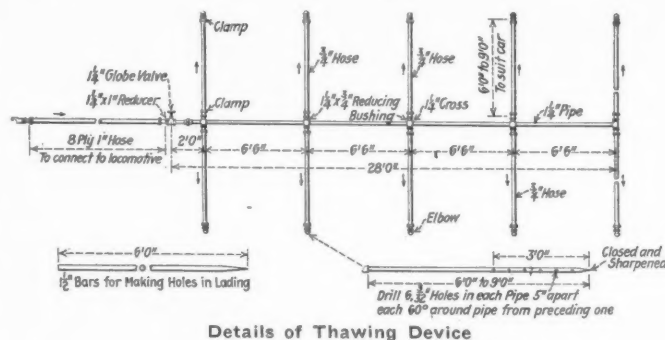
widely, but probably about one-half, or 97,000 cars, will require a general overhauling. The average cost of such repairs is \$1,100 of which \$605 represents the cost of material, \$165 labor and \$330 overhead. The total cost of general overhauling for these cars would therefore amount to \$106,700,000, or more than one-fifth of the total expenditures for freight car repairs in 1920.

Thawing Frozen Hopper Cars

BY E. A. MILLER

During the winter months considerable trouble is often experienced in unloading hopper cars filled with coal, ore, slag, or other bulky commodities which have become frozen. It is only in exceptional cases that conditions warrant the expenditure necessary to build and equip a thawing house and therefore makeshifts are usually resorted to in loosening material from the cars. Sometimes considerable damage is done to the equipment when proper means for thawing are not provided.

The arrangement illustrated herewith can be easily and quickly constructed and serves to loosen frozen lading in the

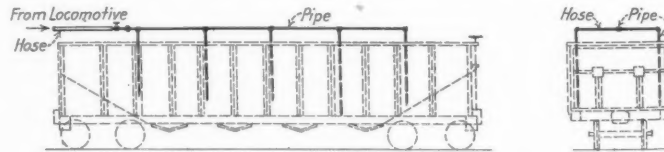


Details of Thawing Device

minimum time and without injury to the cars. As the steam for heating can be taken from a locomotive, the device is applicable in practically any location.

The central portion of the thawing outfit is composed of four pieces of 1 1/4 in. pipe, four 1 1/4 in. crosses and a tee at the outer end. A 1 1/4 in. by 3/4 in. reducing bushing is screwed into each side of the crosses. Leading from each of these bushings is a steam hose securely clamped to nipples at each end. Attached to the outer nipples are pipes 6 ft. to 9 ft. long. The length of the hose should be about the same as the pipe, which should be long enough to reach through the lading to the bottom of the car body. The lower end of each pipe is closed and sharpened and six 3/32 in. holes are drilled, as shown, in a spiral around the pipe.

For connecting to the steam heat line of the locomotive or



Arrangement of Pipes as Used in a Four-Hopper Car

tender, a 1 in. steam hose, about 50 ft. long, should be provided. One end should be fitted with a standard steam heat hose coupling while the other end should carry a 1 1/4 in. globe valve and a union so that the hose may be uncoupled from the thawing pipes whenever necessary. Steel bars, 1 1/2 in. in diameter and about 6 ft. long, are used for making holes for inserting the pointed pipes in the frozen lading.

One of the illustrations shows the application of the arrangement to a four-hopper car. The dimensions can, of course, be varied to suit any other types of equipment.



Successful Methods Used in Repairing Side Rods

Simple Gages Insure Accurate Standards; Methods of Procedure Which Simplify Work and Reduce Costs

BY M. H. WILLIAMS

REPAIRING side rods in the main railway shops has gradually grown to quite large proportions, so much so that the question of facilities and tools to expedite this work should receive careful attention. A number of devices, tools and methods that have been used in different shops and found to be of assistance when making these repairs are explained below.

One of the most important points at the time of repairs is that of laying out the center to center distance of the rod brasses correctly to the established standard called for on the drawings, this distance being the same as that between the axle centers. In order to insure these distances being correct, standards or tram bars for this purpose should be available readily in all shops where this work is done.

Tram Bar

A tram bar used for setting the adjustable points for laying off rod centers, laying off shoes and wedges, setting and proving distances between axle centers, etc., is shown in

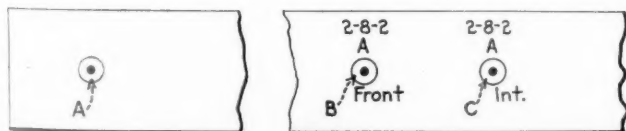


Fig. 1—Tram Bar

Fig. 1 and may be considered a master standard for this purpose. Such a tram bar will be found to be a decided improvement when compared with the practice of setting distances to a rule, scale or tape line. As the center distances for all classes of rods handled in a shop may be placed on

one bar, this tram bar costs less than individual non-adjustable trams for each class of rod. The tram bar shown may be made of 2-in. by $\frac{1}{2}$ in. steel about 8 ft. long. Hardened steel bushings about $\frac{1}{4}$ in. outside diameter with a $\frac{1}{16}$ in. hole drilled in the center about $\frac{1}{4}$ in. deep are set into this bar at proper locations. At *A* is shown the zero bushing that is always used as one of the setting points—the remaining bushings as shown at *B*, *C*, etc., being located a distance from the zero point equal to the standard distance center to center of rod sections. The class of locomotive and rod section are stamped on the bar near the latter bushings for the purpose of indicating them. For example, if locomotives known as 2-8-2-A require a distance of 54 in. for the front section of the rod, the bar is stamped 2-8-2-A FRONT at this place. Another for an intermediate section may be distant 58 in. and stamped 2-8-2-A INT., and so on.

This bar offers a ready and accurate means for setting adjustable tram points used for the tramming of rods and wheel centers or for checking solid trams if they are used. Having a standard of this nature available will reduce the errors that are liable to occur from improper setting of tram points. These tram bars generally are bolted to walls, or work benches at convenient locations in the rod shop, the erecting shop and engine houses.

Correcting Center Distances Between Holes

A number of methods are followed when repairing side rods in the event of the distances from hole center to hole center varying from the standard, the manner of doing this depending upon the machinery available. Either of the two plans mentioned have certain advantages and disadvantages. If the distances between centers are not standard, the first method is to rebores the holes for bushings at the correct

distance of hole center to hole center. Where there is only a small error, say not over $\frac{1}{8}$ in. the method often followed is to press the brasses into the rod and afterwards bore them to agree with the standard tram distance. In this event the bore of the brasses will be eccentric with their outside but the distance between centers will be correct.

If the first mentioned method is used and the rods are bored each time they are found to be out of tram, repeated borings may in time enlarge the holes to the danger point. This, however, is offset by the fact that where the rod is kept to a standard tram distance the brasses may be turned on the outside and bored in one chucking operation, and when necessary to renew a brass the machining may be done in an ordinary lathe, which is quite an advantage in small shops not well equipped.

The second method of pressing the brasses into the rod and afterwards boring has the advantage that it is not necessary to rebore the rod as often and the holes are not enlarged as by the first method. The disadvantages are that when necessary to renew a brass it must be turned to the proper outside diameter, pressed in the rod and the hole bored on a drill press, special rod boring mill or some machine where the boring bar revolves. This is often difficult in the smaller shops not equipped with suitable machines. However, make-shifts are at times resorted to, such as turning the outside of brasses to correct size in a lathe and then setting the brass the required amount eccentric in the lathe chuck and boring the hole to the required size. This plan is not recommended and is only mentioned to show to what extremes it is sometimes necessary to go to in railway work. Considering the question of renewals of brasses as a whole the second plan of boring while in the rods appears to be the more economical and satisfactory.

Refinishing Holes in Rods

When refinishing rod holes they should be enlarged the least amount necessary to true them up and obtain a satisfactory hole. To remove a greater amount of metal will result in unnecessary enlargement and a sooner approach to the danger point where the rod must be scrapped. The question also comes up as to when a hole in a rod is out of round or irregular enough to warrant reboring. Looking at this from a safety standpoint and also that of true brasses would indicate that the bore should be trued when more than 0.015 in. out of round for a 7 in. or less diameter bore, and for larger holes the same ratio should be followed.

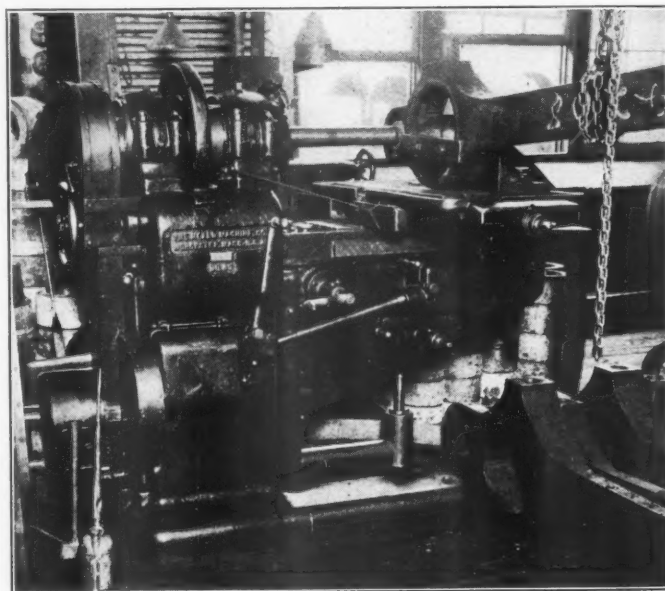
Several methods are followed when truing these holes, one of the more common being to rebore on a special boring mill or drill press, the rod being clamped to the bed of the machine and bored with an adjustable boring tool. The cutters are held in the bar by set screws and adjusted in or set out as may be necessary to obtain the required diameter. This method, where care is used and the drill press or boring mill is in proper condition, will result in good work. It has the disadvantages, however, that there is always the possibility of the workmen removing more metal than necessary, and, unless the machine is in a first class state of repair the holes will not be regular owing to the bar following the irregularities of the original hole. These conditions are improved by making use of a pilot bar working in a bushing in the machine table. This, however, is objectionable on account of the time required to set the rod central with the bushing in the table. The double cutter adjustable boring bar similar to that used for boring car wheels is also used for this purpose and in many respects is superior to a bar in which the cutter is held by a set screw.

One of the best and most up-to-date methods of doing this work is to grind the rod holes on a Heald or similar internal grinder. With this machine the rod is clamped to an angle plate hold on the machine table. The table is then set by means of the table adjusting handles similar to adjusting

a milling machine table so that the hole in the rod is central with the grinding wheel rotation. The grinding operation is then performed which consists of truing the bore only enough to remove irregularities and not enlarging the hole more than absolutely necessary. On account of the small amount of time required to clamp, adjust and grind the total time to finish a hole will generally be less than when bored. On account of its many advantages this form of machine is strongly recommended for this class of work.

Measuring Sizes of Rod Holes and Brasses

Several methods are used for measuring the diameter of the holes for rod work. This usually has been done in the past with machinist's calipers, the amount allowed for the force fit of the brass in the rod and the amount the bore of the brass was made larger than the crank pin being a question of the skill and judgment of the workman. The modern



Grinding Knuckle Pin Hole

method for taking these measurements is to use micrometer calipers. By their use the diameter of the holes is measured at various angles and should the bore not be regular the average diameter may be calculated and followed. Such measurements will show the exact amount a hole is out of round or irregular, and where standards have been set governing this matter the necessity for reboring will at once be settled by the difference in these measurements. Also when machining the brasses, they are made a definite amount larger than the rod bore in order to insure a correct force fit. No standard practices appear to have been determined for force fits for rod brasses but on some roads from 0.002 to 0.003 in. is allowed for each one inch diameter of rod bore.

Size for Rod Bore

Practically every rod brass must be bored to a different diameter owing to the wear of the crank pins on which they are to work. In order to insure the bore being correct and to avoid the necessity for the boring mill operator leaving his station to go to the driving wheels and take crank-pin sizes, it is the practice in some shops to measure the crank pins with micrometer calipers and set down the sizes on a specially prepared blank or memorandum. The boring mill operator then bores the holes a suitable amount larger than the sizes given to allow for a running fit between the crank-pin and brasses.

Crank-Pin Sizes

Crank-pins that have been in service are often found to be out of round or tapered as a result of wear. However,

a slight discrepancy in diameter will not justify removal or refinishing. It is an open question how much crank-pins may be worn before repairs are necessary. On some roads they are not repaired until they are more than $1/32$ in. taper or out of round which appears to be a good practice. When measuring the pin diameter the largest size measured is used when determining the diameter for boring the brass.

Tramming Rods

Practically all side rods when in the shop for repairs should be trammed in order to insure the distances between hole centers being correct. This generally is done in the following manner. The rod sections are laid in a straight line

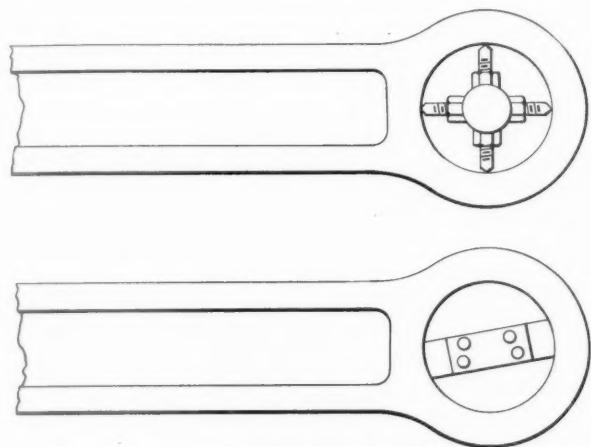


Fig. 2—Centers for Tramming Rods

on a trestle or some convenient place and coupled up with the knuckle pins. Pieces of wood about $3/4$ in. square are cut to the proper length to fit the rod or brass bore and fitted tightly in place—these wooden blocks having tin tacked on one side for marking upon. In other cases adjustable centers are used. Both of these devices are shown in Fig. 2. The centers of the holes in the rod or brasses are then laid off on the surface of the tin tacked to the wooden blocks or the adjustable centers set and the distance between the two centers checked with tram points that have been set to the standard tram bar. Should the distances not be correct the centers marked on the tin face are altered to agree with the tram and circles are marked around each hole to serve as a guide when reboring and proving the accuracy of the work.

When laying out for brasses that have been previously pressed in a similar plan is followed, the circles being scribed on the brasses and the bore then made exactly concentric with these circles.

Fitting and Boring Rod Brasses

Where it is the practice to rebores the holes in rods and restore the correct distance, the brasses are turned on the outside to a proper diameter for a force fit in the rods and also finish bored to a size suitable for a running fit on the crank-pin. When following this practice allowances are made for the closing of the bore of the brasses when pressed into the rod, this closing being from 25 to 75 per cent of the amount allowed on the outside for a force fit. Exact allowances readily can be made by the use of micrometer calipers and a proper fit obtained between the brass and the crank-pin. Where the brasses are bored while in the rod, the operation is similar to that described for boring rods and the same style of boring bar is used, the bore being made in the exact center of the circle scribed on the brass.

Refinishing Knuckle Pin Holes

The limited space that can be given for side rods has made it necessary in many cases to design the knuckle pins and

bushings smaller than is desirable. Therefore, the fitting of the pin and bushing should be as nearly perfect as possible, for, unless this work is properly done these parts will loosen in service and cause trouble. In order to obtain the desired grade of fitting too much stress cannot be placed on the question of maintaining the reamers used for this purpose to the proper taper. The holes when reamed should be as near perfect as possible to insure a full bearing for the pin instead of only bearing in spots. Such conditions being essential the next question is how to meet them.

Accurate gages of a design which admits of quickly inspecting the taper holes results in a higher standard of rod reaming. It is a good practice to check each rod with a gage at the completion of the reaming operation to detect at once errors such as may occur as a result of wear or improper grinding of reamers, reamers running out of true in the drill press or from other causes. This inspection together with proper reamer maintenance results in ultimate economy owing to the reduced time required when machining the knuckle pins as one setting of the taper attachment of lathe or table of grinding machine will answer for the entire lot of pins of the same taper and eliminates the many trial fittings of pins now common where gages are not used.

Gages for this purpose are made in a number of forms. For convenience when handling, detecting errors in taper of holes, and measuring their diameter the flat form shown in Fig. 3, has been found satisfactory. This form weighs less than the cylindrical form which is a desirable feature and slight errors are more readily detected. This gage is made from tool steel hardened or soft steel case hardened. The taper per foot is the same as that of the rod to be measured, the thickness about $3/8$ in. and the small end diameter the same as the small end of the taper of standard rods made to drawing sizes, i. e., when placed in the rod the point will come flush with the lower side. The length is governed largely by the amount that the taper holes may be enlarged

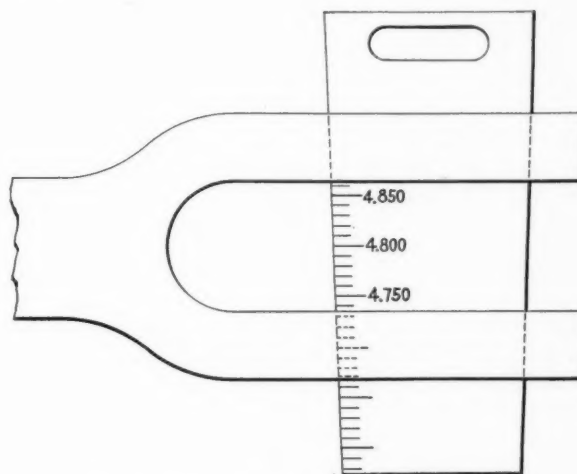


Fig. 3—Taper Gage for Knuckle Pin Hole

without endangering the safety of the rod. As an illustration assume that the small end of the taper hole in the rod is $3\frac{3}{4}$ in. diameter, that this diameter may be increased $\frac{1}{4}$ in. or to 4 in., that the taper is $\frac{3}{4}$ in. per ft. and that the out to out thickness of the rod is 4 in. The taper of $\frac{3}{4}$ in. per ft. equals $1/16$ in. per inch length. Therefore for $\frac{1}{4}$ in. enlargement of the hole the gage must be 4 in. longer than the thickness of rod. Consequently, for the rod in question, the gage should be about 9 in. long to allow for 4 in. width of rod, plus 4 in. that the gage will extend through a large reamed rod, plus about 1 in. for hand hold.

It is desirable when finishing the taper ends of knuckle pins to know their exact diameter at some particular point. This is measured easily by gages of this design when one

edge is graduated and stamped to show the actual diameters of the taper surfaces. Generally speaking these are graduated to show each 0.010 in. increase in diameter, i. e., if the first line indicates $3\frac{3}{4}$ in. or in decimals 3.750, the diameter at the next line will be 3.760 in., the next 3.770, etc. The correct spacing of these graduations can be calculated readily for any taper required. With the gage in question having a taper of $\frac{3}{4}$ in. per ft. (equal to $1/16$ in. per in. or a ratio of 16 to 1) the distance from graduation to graduation for 0.010 in. increase will be 0.010 multiplied by 16 or 0.160 in. Therefore these graduations should be placed this distance apart and for the rod in question they should be extended for about 4 in. making 25 graduations.

Use of Knuckle Pin Gage

The general practice when inspecting taper holes is as follows: After placing the gage in the hole it is given a slight rotary motion, say $\frac{1}{8}$ turn, to center it in the hole so that its center line will assume the position of the true center of the hole. Next the large and small ends are each tried in turn for side or rocking movement. If there be an absence of side movement at both ends this proves that the reaming is correct. Should there be side movement at the large or small end, however, it shows that the hole is not properly reamed. A slight error in taper being quite perceptible by this side shake, the rods may be inspected more quickly than by the customary cylindrical gages. When the gage is placed in the taper rod hole the graduation nearest the inside of the smaller jaw is noted and the actual diameter read direct from the gage, this size being used when finishing the taper end of the knuckle pins.

Fitting Knuckle Pins to Side Rods

It is not the purpose to explain the process of manufacturing these pins, it being assumed that they have been blanked out in the central production shop or point of manufacture, that extra metal has been allowed for the final fitting to the taper ends, that the straight or bearing surface has been finished to standard gages, and that the pin has been threaded, drilled and all work done so as to reduce the rod shop fitting operation to the lowest limit, and thus practically confine their work to the taper ends.

It is a question if any machine will be found as accurate and economical as the plain cylindrical grinder for finishing the taper ends of these pins to fit the rod. This machine has the advantage that either hardened or soft pins may be finished equally well. Therefore the pins may be hardened in quantities during the course of manufacture. Where the work of fitting is done on these machines the method is as follows. The grinding machine table is adjusted to the taper required, such as $\frac{3}{4}$ in. or 1 in. per ft., this taper being set approximately correct from the graduation and afterwards given the final setting from the trial grinding.

The first operation when fitting the pins is to measure the diameter of the taper hole in the rod with the taper gage as has been explained, the size being taken at the inside of the smaller jaw. When grinding, the smaller of the two tapers is first ground to the size shown by the gage plus 0.001 in. to 0.002 in. to allow for drawing up, the diameter of the taper surface being measured with micrometer calipers as shown in Fig. 4. After the required size is obtained, the micrometer dial on the grinder, or the throw-off stop governing the in-feed of the grinding wheel is set to the throw off stop or zero mark and the grinding operation is then transferred to the large end. When grinding this end the wheel is fed in to the previous setting of the throw-off stop or zero mark. This results in the two ends being to the same taper and, where the machine is properly set and the pin size measured correctly the pin will fit the hole in a satisfactory manner. With an operator accustomed to this work 90 per cent of the pins will fit the rod at the first trial. As

the taper ends of knuckle pins are comparatively short it is the usual practice to use grinding wheels slightly wider than the surface to be ground, the wheel being fed directly into the work without lateral motion. The accuracy of this work is governed to a large extent by the size, weight and rigidity of the grinding machine. Therefore, machines smaller than the size known as 10 in. by 36 in. are not recommended.

Where grinding machines have not been installed, this machining on soft pins is done in a similar manner by turning on a lathe, making use of the taper attachment and measuring as explained.

It will readily be noted that where the taper holes in the rods have been reamed to one taper a large batch of pins

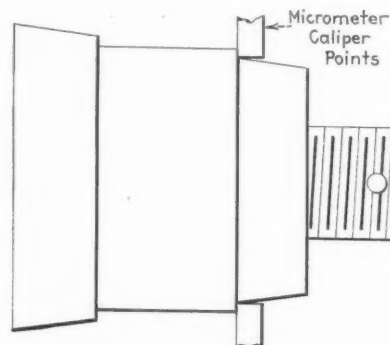


Fig. 4—Calipering Knuckle Pin

may be finished at one setting of the grinding machine table or taper attachment of the lathe and also that by the use of the gage by which the actual diameter of the taper hole can be measured, trial fittings common to cruder methods can be practically eliminated, resulting in saving considerable time.

Fitting Knuckle Pin Bushings to Rods

It is assumed that these bushings have been made in the central shop the same as the pins, to as near a completed state as possible, that is, the blanked out, oil holes drilled, oil ways milled, case hardened inside with ends and outside soft, the bore ground to plug gages the correct amount larger than the pin body to allow for a running fit between the bushing and pin, or, if soft steel or brass bushings are used it is assumed that they have been semi-finished up to the same point. With bushings semi-finished as above, the work in the rod shop is confined to machining the outside to fit the rods.

In order to obtain a perfectly cylindrical bore in the bushings the bore of the rod into which they fit should be ground or reamed if out of true more than 0.010 in. When machining the knuckle bushings the rods are preferably measured with inside micrometers and the outside of the bushings turned or ground about 0.0015 in. larger per inch of diameter to allow for a force fit, the latter being measured with outside micrometers. The bushings are now ready to force into place which completes the rods.

Interchangeability of Knuckle Pins and Bushings

Mention has been made of pins having bodies ground to gage sizes and also bushings with the bore ground to plug gage sizes. This is somewhat of a departure from the conventional methods followed but it works out very well in practice. It must be borne in mind that these two must bear a certain relation to each other in order to insure satisfactory service on the locomotive. This relation can be obtained when manufacturing in quantities cheaper than where each pair is fitted individually. The customary plan with interchangeable manufacture is to make the pin bodies of each class to definite sizes, such as 4 in., $4\frac{1}{8}$ in., etc.,

care being taken to allow only a small tolerance that should not be over 0.002 in. The bushings are ground, or, in the absence of grinders, bored and reamed about .012 in. larger than the pin diameter, maintaining the same tolerances. These limits are not difficult to live up to in quantity production. The bushings will compress a certain amount when pressed into rods which will reduce the diameter of the bore. This is a question that must be looked into for each class of rods in order to insure a proper running fit of the pin. However, with the amount the bore should be larger than pin once settled and these parts made to the required sizes all the work of fitting the pin to the bushings is removed from the rod shop and transferred to the manufacturing department where it can be done at less expense.

Malleable Castings Improved by Research

The American Malleable Castings Association inaugurated an intensive research program a few years ago in order to improve the quality and reliability of its product which at that time was unfortunately frequently of a very uncertain character. A central laboratory was established and Enrique Touceda, Albany, N. Y., was engaged as consulting engineer and metallurgist. With the aid of a corps of assistants and inspectors investigation was made of the foundry practices of the different members and improvements made as rapidly as investigation demonstrated their value. Test bars were regularly submitted by all manufacturers. Bulletins containing reports, and recommendations were sent out periodically.

As a result of this work malleable castings as at present manufactured in conformity to association standards, instead of being of uncertain quality and lacking in uniformity, are of the highest quality and integrity. They are on a plane of dependability with the best mild steel castings or forgings, while they can be machined at almost double the speed of either.

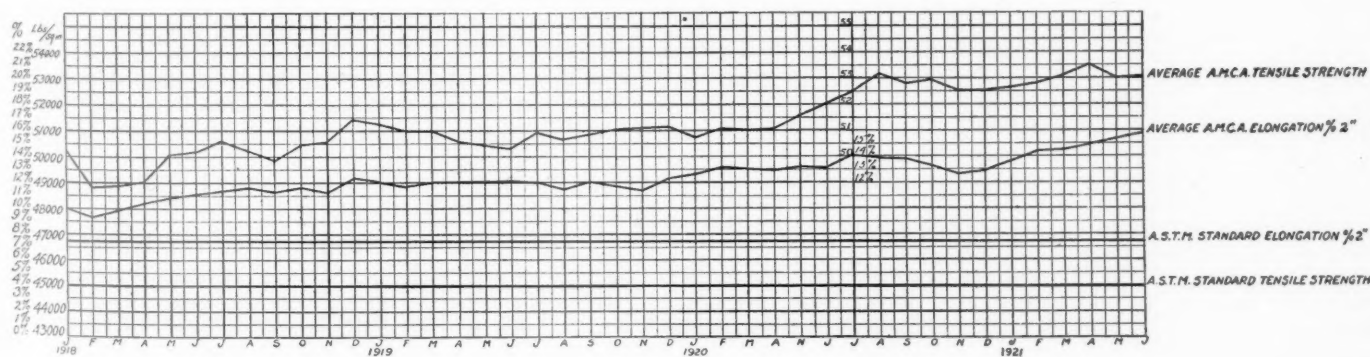
A bulletin just issued shows the most marked advance in development has been made in the past three and one-half

will be seen that this report marks a new high level in the research program. Since the first of the year, the rise in percentage of elongation has been steady and uninterrupted, and has increased a full two per cent. The high water mark for average ultimate tensile strength was reached in April of this year when the figure of 53,530 lb. per sq. in. was recorded. The June value for this property was 53,038 lb. or 8,000 lb. in excess of the A. S. T. M. requirements.

A reference to the accompanying chart showing average ultimate tensile strength and elongation for the product of the membership as a whole for 1918, 1919, 1920 and the first six months of 1921, indicates clearly how these two properties have increased during this interval. The average of both properties has always been well in excess of the A. S. T. M. standard requirements of 45,000 lb. per sq. in. tensile strength and 7½ per cent elongation in two inches. It is clear that this margin when added to the factor of safety already included in the standard specifications, offers exceptional safeguards to the user of those malleable castings furnished by a majority of the members of the association.

A study of this chart will show that during the year 1918 there was recorded a gradual increase in both tensile strength and elongation, with a slight retrogression from July to October. During 1919 and the spring of 1920, both properties remained fairly constant, averaging around 51,000 lb. tensile strength and 12 per cent elongation. From April, 1920, to August of the same year, both properties increased to values never before reached, the tensile strength increasing from 51,000 lb. to over 53,000 lb. when a slight depression set in extending to the month of November, since which time the increase has been regular with one slight interruption in tensile strength. It will be noted that the two curves run fairly parallel, rising and falling together, a characteristic of malleable iron which is rather unusual for ferrous materials, the reverse normally being true.

The constancy in the average values of these properties maintained throughout 1919 and the spring of 1920, with little apparent improvement over a period of several months, is accounted for by the fact that during that time twenty-two new plants were added to the list of test bar contributors.



.. Average A. M. C. A. Ultimate Tensile Strength and Elongation by Months

years, during which period the product of association members as a whole has increased from an average somewhat under 49,000 lb. per sq. in. ultimate tensile strength to over 53,000 lb. and from an average elongation under 10 per cent in two inches to nearly 16 per cent.

The bulletin covers the report of bars tested by the consulting engineer for the month of June, 1921, when the highest average percentage of elongation of the association as a whole was attained, namely, 15.77 per cent in two inches, or over twice the elongation required by the American Society for Testing Materials in its standard specification for malleable cast iron. Since elongation, which is the measure of ductility, is the property on which malleability depends, it

None of these had previously profited by the research work, and their submitted test bars in most cases had the effect of lowering the general average of the association, until after such time as the effect of the new influence began to assert itself. The same effect was felt from August of 1920 to December, when four new contributors were added. No new contributors were added from April, 1920, to August of the same year, nor during the period from December of 1920 to June of this year. This fact taken in conjunction with the improvement in quality of the new contributors through the assistance of the consulting engineer and his corps of visiting inspectors, had the effect of a steady and rapid increase in both physical properties. The slight retrogression in the

average values of both properties marked by the dropping of the curves from August to November of 1920, is explained by the difficulty in getting good pig iron and coal during that exceptional period of demand for all commodities.

Another interesting fact is the high percentage of perfect scores made by the members of the association. By a perfect score is meant the ability of every bar submitted by a member to equal or surpass the standard specifications of 45,000 lb. tensile strength or $7\frac{1}{2}$ per cent elongation in two inches. In June of the present year 87 per cent of the contributors made perfect scores. Comparing this record with those for the same month of the previous years, it is found that perfect scores were attained by but 29 per cent of the contributors in June of 1918, 57 per cent in 1919, and 74 per cent in 1920. Out of a total of 31 contributors in June, 1918, of whom 29 per cent attained perfection, all but one made perfect scores in June of the present year. Only 2.53 per cent of all bars cast and submitted for test during June failed to pass the standard A. S. T. M. specifications as against 15.12 per cent for June, 1918.

This general improvement of the product of all members is reflected in the number of certificates that were awarded for the quarter ending June 30; sixty-one plants having been awarded the coveted certificate, the highest number yet issued for any one quarter. The awarding of a certificate is not based upon the test bar record alone; the general plant practice as reported by the consulting engineer's corps of inspectors being considered in its effect upon the product. Through this safeguard, the purchaser is assured that the test bar record of each day's production can be considered as truly representative of the castings. Castings furnished by certificate holding plants are designated as "certified" malleable castings.

Nothing could more clearly indicate the value of a research program consistently carried out and rigidly applied than a comparison of this most recent report with those that have preceded it. The net result of this work has been to raise to a high level the standards of a great industry, and to increase materially the commercial applications of its product.

Feed Valve Testing Device

BY NORMAN McCLEOD

The testing of feed valves used in air brake service, after they have been repaired has been accompanied with more or less annoyance inasmuch as it requires more dexterity than the average man possesses. To save time in applying and removing feed valves from the testing rack the device, illustrated, has been developed and used with good success.

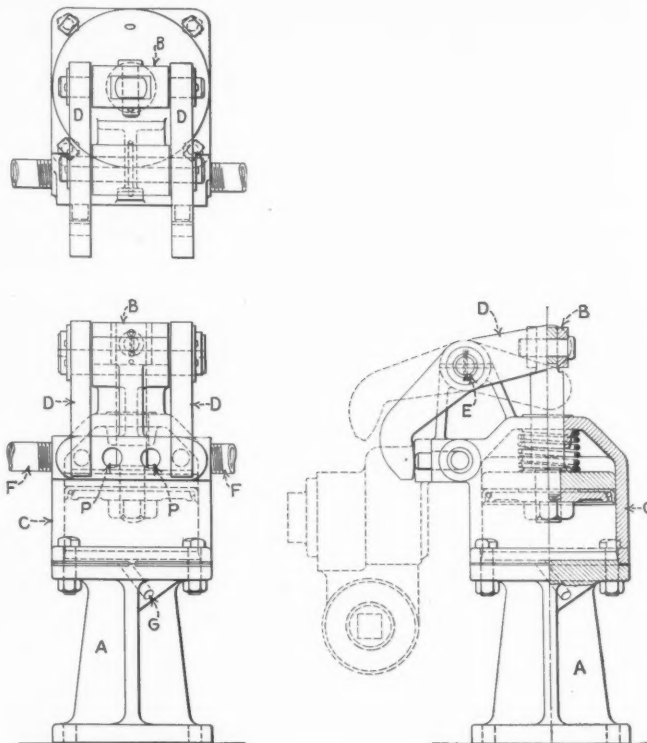
The device consists of a cast iron base *A*, fastened permanently in a vertical position to the air brake test room bench in a position where it can be connected to the testing equipment through pipes *FF*. Provision is made to cut these out of service if need be by having $\frac{1}{2}$ -in. globe valves or cocks located on each side of the device. The top of casting *A* is machined to receive a $3\frac{1}{2}$ -in. bore cylinder *C*, provided with a piston, follower head, distributing valve packing leather and spring, all being taken from the standard stock of air brake parts. Attached to the outer end of the piston rod is a cross bar *B*, on each end of which are two lever clamps *DD* which oscillate on shaft *E* which is in turn supported on a projection forming part of the cylinder casting.

At the side and near the top of the stroke of the piston, on the cylinder casting, a projection is provided with two portholes *PP* and dowels to correspond to the bolt holes in the face of the flanged rectangular face of the feed valve.

The main idea of developing this device was to facilitate

the holding of the feed valve in place while the operator was looking after the test, reading gages, etc., which could not well be done if the operator had to hold the valve against a fitting or lose time tightening and loosening fluts.

With this device, the operator places the feed valve bolting flange with the bolt holes over the dowels on the tester, thus bringing the ports in the machine and valve in line (a permanent metallic gasket being always on the machine). With the other hand the operator opens a $\frac{1}{4}$ -in. air cock located at or near *G*, this cock being connected to the air pressure system. This piston is then forced outward a distance of $1\frac{1}{8}$ in., pushing the cross arm *B* which in turn takes the two lever clamps *DD* with it. This causes the



Feed Valves are Readily Clamped on This Device for Testing

lower ends of the clamps to press hard against the flange of the feed valve and hold it tight enough to form an air-tight joint, thus holding the feed valve in place while the operator subjects it to the usual prescribed test.

Upon closing the small valve referred to above, the coiled spring forces the piston back to open position, the exhaust air passing out of a porthole provided for the purpose in the cock or valve. In the meantime the feed valve has been released. This feed valve testing device has proved a great source of convenience as well as a great saver of time and money.

HENRY FORD's entrance into the field of steam railway transportation, through his acquisition of the Detroit, Toledo & Ironton, has aroused a more intense public interest than any other single recent event in railroad history, not excepting the advent of federal control at the beginning of 1918. His success as a manufacturer in a field in which, through great ability and highly standardized factory methods, he has built up a vast business, has given him an international reputation such that his opinions on any industrial subject are received with great respect by the public.

Mr. Ford has purchased a railroad which never before had demonstrated that its existence as a common carrier was economically justified. He raised the wages of his railway employees when other roads were adopting reduced wage scales. He has made a 20 per cent reduction in local freight rates and has started a movement for a general rate reduction.



A View of the Exhibit at the Steel Treathers' Convention

Steel Treathers Meet at Indianapolis

Convention Featured by Large Attendance, Interesting Papers and a Comprehensive Exhibit

THE Third Annual Convention of the American Society for Steel Treating was held in the Manufacturers' and Women's Buildings, State Fair Grounds, Indianapolis, Ind., September 19 to 24, inclusive. Prominent metallurgists and steel treathers both of the United States and Europe were present, the total registration of delegates, visitors and guests being well over 4,000. Eighty-seven papers relating to steel treating in its various phases were read and presented by title, simultaneous sessions being held on several afternoons to allow time for reading and discussing the large number of papers. The exhibition was of exceptional size, interest and value, approximately 80 manufacturers exhibiting heat treating equipment and products ranging from immense electric and gas furnaces to small scleroscopes, steel drills and cutlery.

The entertainment program was featured by a 50-mile match race Wednesday morning on the Motor Speedway, between Duesenberg and Frontenac motor cars. The race was exciting, being won by Wilcox in a Frontenac car at an average speed of 95.4 miles per hour. Another interesting feature was a smoker and vaudeville entertainment, Tuesday night.

The annual banquet was held Thursday night in the Riley Room of the Claypool Hotel, being presided over by Lt. Col. A. E. White, with Dr. Albert Sauveur as toastmaster. The speakers included Gov. W. T. McCray of Indiana; Hon. C. W. Jewett, Mayor of Indianapolis; H. E. Coffin, vice-president of the Hudson Motor Car Company and a member of the Naval Advisory Board, and others. The principal address of the evening was on "Our Air Policies and the National Defense," by Mr. Coffin, who said that the cornerstone of national security lies in peacetime industrial organization against a possible wartime emergency. "No nation, however warlike, will assail a nation known to have its industrial resources efficiently organized for defense," said Mr. Coffin. In connection with the address some interesting moving pictures of the aerial bombing and sinking of the German battleship *Ostfriesland* and other battle cruisers were shown.

The opening session of the convention was held Monday at 2 P. M., convention delegates being welcomed to the city by a representative of the Mayor. This address was followed by a response by Lt. Col. A. E. White, national president of the society, when the members listened to the report of tellers of the election. The following officers were declared

elected for the ensuing year: F. P. Gilligan, Hartford, Conn., president; F. C. Lau, Chicago, 1st vice-president; R. G. Allen, Springfield, Mass., 2nd vice-president; J. B. Emmons, Cleveland, Ohio, treasurer; J. J. Crowe, Philadelphia, Pa., director. The holdover officers are Lt. Col. A. E. White, retiring president, who automatically becomes director for two years; W. H. Eiseman, Cleveland, Ohio, secretary; H. J. Stagg, Syracuse, N. Y., director; E. J. Zanitzky, Chicago, director. The reports of the secretary and treasurer were read, being followed by the address of Lt. Col. A. E. White.

President's Address

"I take pleasure in presenting for your consideration a statement of the work of the American Society for Steel Treating. I further take the liberty of incorporating in this report various recommendations and suggestions relative to the conductance of the work of the society during the coming years, to which it is trusted that your national and local officers will give due consideration.

"The year has been a most successful one for the Society. The combined membership at the time of the amalgamation of the American Steel Treathers' Society and the Steel Treating Research Society was approximately 2,750. On September 1, 1921, the membership of the American Society for Steel Treating was 3,237. This represents an increase of 487 members during the past 12 months' period, or an increase of substantially 18 per cent. Appreciating the unusual conditions which have existed during the period, a growth of this magnitude is both surprising and gratifying.

"Our chapters also have increased in number from 27 to 31, the new chapters taken in being in Syracuse, N. Y.; Charleston, S. C.; Worcester, Mass., and Gary, Ind. Our financial status is sound with a sufficient balance on hand to carry us over any untoward periods, should such develop.

"It is prerogative of the President at this one time to incorporate in his report such suggestions as he believes may be for the good of the Society. In this connection, I would bespeak an arrangement of this magazine (*Transactions of the American Society for Steel Treating*) so that it may cover more adequately even than it does today the field of heat treatment. It is my personal feeling that in its pages we should cater to the technical men and to the shop men. Our articles though not necessarily in the same contribution should be of interest to both and they should be arranged

so that there will be no misunderstanding relative to the purposes for which the articles are prepared.

"There is an old saying, 'In union there is strength.' This seems to be the case with our technical societies, but I have noted where our chapters are in close alliance with other technical societies in their own communities there is always a successful chapter. Further, I have noted that our weaker chapters are for the most part those which exist in communities where there is no bond of union between the technical societies. In view of this condition I therefore strongly recommend to the various chapters in the society that they make every possible effort to co-operate with the various technical societies in other communities and unite with them by alliance wherever this is possible."

The following are abstracts of some of the papers presented:

Physical Tests of High Speed Steel

BY A. H. d'ARCAMBAL

Metallurgist, Pratt & Whitney Co., Hartford, Conn.

Transverse tests at room temperature and tensile tests at temperatures ranging from room temperature to 1,200 deg. F. were conducted on two types of high speed steel, namely, the 18 per cent tungsten, 1 per cent vanadium type; and the 14 per cent tungsten, 2 per cent vanadium grade. The specimens were given different hardening treatments, and after being tested, the fractures were examined, samples file tested, and micrographs made on samples given the various heat treatments.

The transverse tests showed that samples quenched from a high temperature and drawn to 1,100 deg. F. possessed the necessary hardness and gave a high fibre stress, showing almost double the strength of specimens quenched from the same temperature and not drawn. Quenching into a bath at 1,100 deg. F. and not drawing, gave about the same fibre stress and exactly the same microstructure as samples quenched into oil and not drawn. Several specimens in the undrawn condition could not be tested, due to the presence of grinding cracks caused by strains in the material.

Tensile test specimens, quenched from a high temperature, and drawn to 1,100 deg. F., showed the maximum tensile strength when pulled at 600 deg. F. Specimens quenched from the high temperature and not drawn, gave about 70 per cent of the tensile strength of samples quenched from the same temperature and drawn to 1,100 deg. F. before being tested at room temperature. Specimens given the high quenching treatment, but only drawn to 450 deg. F. possessed only a slightly higher tensile strength than specimens in the undrawn condition.

The higher vanadium type of steel gave lower transverse and tensile readings than the 18 per cent tungsten grade. This was due to some extent to the former type of steel not standing as high a quenching temperature as the higher tungsten type of steel, thus being slightly overheated, as shown by the fractures.

The Toughness of High Speed Steels as Affected by Their Heat Treatment

BY M. A. GROSSMAN

Metallurgist, Electric Alloy Steel Company, Youngstown, O.

Data are presented constituting the results of toughness tests on two high speed steels of common analysis. The tests were carried out on an impact machine of the Charpy type, on test bars which resembled the standard Charpy bar, unnotched.

A considerable number of test pieces were hardened and

drawn, covering the quenching range from 1,700 to 2,250 deg. and the drawing range from no draw to 1,100 deg. For each quenching temperature a series of test pieces was drawn at all the drawing temperatures. It was found that there is a certain quenching temperature slightly below the proper hardening range for which the steel is brittle on being quenched and acquires no toughness on being drawn up to 1,100 deg. Below this quenching range, drawing imparts toughness but lowers the hardness. Above that range, drawing at 1,100 deg. imparts toughness while at the same time developing secondary hardness. The toughness tests and the hardness tests were carried out on the same test pieces.

Curves are given showing the changes in toughness for the different heat treatments and the change in scleroscope hardness for those heat treatments. The data show:

(1) That the development of secondary hardness in the proper hardening range is accompanied by an acquiring of toughness which may properly be called "secondary toughness," and

(2) that just below the proper hardening range there is a range of temperature which, while giving quite good hardness, results in the steel being brittle and remaining so even with subsequent drawing to 1,100 deg.

What Insulation Will Do for the Heat Treater

BY J. T. COWER

Armstrong Cork & Insulation Co., Pittsburgh, Pa.

The benefits which are derived from the use of heat insulating materials can hardly be over-estimated. A few of the most prominent of these are:

(a) Insulation increases the capacity of equipment with no increase in fuel consumption.

(b) Insulation makes temperatures more uniform in heated equipment.

(c) Insulation decreases the time required to bring equipment to the working temperature.

(d) Insulation, in many cases, lengthens the life of refractories by eliminating the necessity for overheating in the combustion chamber.

(e) Insulation makes more comfortable working conditions by reducing air temperatures around the heated equipment.

The various factors governing heat losses through conduction are discussed and formulated mathematically.

Grinding Sparks as a Measure of Carbon Content

BY D. H. STACKS

Consulting Metallurgical Engineer.

The quality of iron and steel to produce sparks under certain conditions is acknowledged as ancient history. When a piece of iron or steel is pressed against a fast revolving grinding wheel, minute particles of metal are removed and thrown into space which are observed as Lines of Fire and which seem to become molten and finally disappear—in case of an almost carbonless iron—shaped like a steel needle with the point in the direction of flight and slightly tipped at the end on account of the rapid cooling effect of the atmosphere. In case the iron contains a small amount of carbon the needlelike effect is broken up with an explosion and little lines of fire dart out of what was originally the needlelike body. As the carbon increases, these secondary lines of fire again explode causing further subdivisions and the action continues as the carbon increases, until all that can be observed is a mass of explosions.

When steels contain alloys, such as nickel, chromium, vanadium, manganese, etc., the lines of fire and the spark

explosions are more or less interrupted with less line of fire and smaller as well as larger explosions.

When all conditions are standardized, and by the use of known standards and with the personal equation eliminated, the inspection of steel can be successfully carried out by placing the unknown composition along with the known upon a specially designed automatic machine which will throw out two lines of fire and spark explosions simultaneously in such a manner that the carbon content of the unknown will be plainly observed for any commercial specification of steel commercially accurate.

Figures which represent over 100 determinations of open-hearth furnace checks and factory control work show that the average spark carbon results are identical with the combustion carbon, with the individual determinations checking on the average within 0.025 plus or minus and with but two extremes of 0.04 and 0.05 per cent of carbon variation from the standard combustion results.

The Electric Furnace as It Affects Overall Cost of Heat Treated Parts

BY C. L. IPSEN

Designing Engineer, General Electric Company, Schenectady, N.Y.

In the development of steel treating furnaces there has been a progressive change from one form of heat source to another, starting with wood and going on through coal, oil and gas, to electricity. Each change has been to a higher priced fuel, indicating that there are factors more important than fuel costs in steel treating. A table is given showing the over-all cost of several heat treated parts and the percentage of this cost that is chargeable to fuel. A small improvement in quality, reduction in rejections or saving in subsequent operations will in most cases cited many times offset the increased cost of improved heat source.

Electricity is the ideal heat source for steel treating because (1) the temperature of heat source is only slightly higher than parts being treated, so that no part can be overheated; (2) absolute temperature uniformity can be maintained; (3) the human element is reduced by the use of accurate and reliable temperature control.

In the selection of any furnace first consideration should be given to cost and quality of finished part, as it will in most cases show that the highest priced heat source is the least expensive.

The Efficacy of Annealing Overstrained Steel

BY I. H. CONDREY

Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Steel is composed of granules of crystalline material inclosed in thin envelopes of non-crystalline or "Amorphous cement." This "amorphous cement" is hard and strong but brittle, and tends to impart properties to the metal in proportion to the quantity present.

During overstrain motion occurs between adjacent portions of the granules, which results in the transformation of some of the originally crystalline metal into the amorphous state. Hence, overstrained steel becomes harder and more brittle, hence less resistant to shock. These are undesirable properties. It is customary to anneal many steel parts periodically.

Tests have been made to prove the efficacy of such treatment and the results lead to the following conclusions:

1. Overstrain of metal when its temperature is below the transformation range results in the production of undesirable properties tending to render the metal unfitted to withstand sudden and shock loads.

2. If possible such effects should be eliminated for the safety of those using devices which have been so abused.

3. Proper annealing suffices to completely restore the normal properties of low carbon steel even after the most severe overstrain.

The Heat Treatment of Copper and Brass

BY F. H. HELRIGEL

Metallurgist, Motor Products Company, Detroit, Mich.

The heat treatment of copper and brass, like the training of a child, begins before it is born. There are certain elements introduced into the metals from the ores which no amount of commercial refining will eliminate and which almost entirely govern the quality and use to which the metals can be put.

Copper occurs as pure metal, and as sulphide or carbonate. It is first roasted and then reduced to metal, much as iron is reduced in the blast furnace and later converted to steel in the open hearth. Very few impurities are present in copper. Zinc occurs as sulphide and carbonate and is reduced by distillation. It is from zinc that most of the impurities of brass are obtained; bismuth, arsenic, cadmium, iron, lead and tin occurring most often.

Brass is manufactured by melting up copper in crucibles or furnaces, adding to it scrap brass and zinc and pouring, either into castings or into forms for further working. Every quality that a brass casting must possess is imparted to it by its chemical composition. It cannot be heat treated. Brass that is to be used for sheets, strips, tubing, etc., is further rolled, annealed, pickled and the process repeated until reduced to size.

One might state as final and conclusive that there is no such thing as heat treatment of copper and brass, that it can only be annealed, and if the metals were pure and annealing conditions ideal that would be so. However, foreign elements in brass, intentional or otherwise, almost govern its treatment. Iron and lead are to brass what phosphorus and sulphur are to steel, as to machining qualities, hardness and tensile strength. Manganese plays much the same role in each. Brass annealed dead soft, containing tin or iron, has a much higher tensile strength and hardness than pure brass. Other factors governing the annealing are degree of hardness, due to cold working, time and temperature. While the annealing of brass is a simple straightforward proposition, it requires a sympathetic understanding of what ails the metal to treat it accordingly.



Idle Locomotives—Built in England for War Service in France—Too Heavy for Service in England

The Effect of Temperature in Case-Hardening*

A Discussion of the Relation of Temperature to Quality of Case and Core in the Carbonizing Process

BY THEODORE G. SELLECK

IN discussing this subject it is important that we have a clear idea, first of all, as to what is meant by the terms "case" and "core" of carbonized steel, and what their physical and chemical characteristics are.

In all carbonizing operations there is or should be left a portion of the metal in its original condition; that is, a part of the metal is not allowed to carbonize, being prevented from so doing by the shortening of the carbonizing period; hence the steel in that section remains or should remain in the condition it was in before the operation began. Such section of the metal is called the "core," while the carbonized and hardened surface is called the "case."

The low carbon core of case-hardened steel imparts the ductility necessary to resist breaking strains, while the case furnishes a hard surface for resistance to wear, this combination furnishing parts that combine those two important qualities as no high carbon steel could, and at the same time permitting rapid and easy machining. This fact, of economical machining of parts out of soft material, is the real reason for the high importance case-hardening has attained as a manufacturing process.

Proper Heat Treatment Absolutely Essential

The temperatures at which the steel is carbonized, and heat treated, have a marked effect upon the physical qualities of both the case and core since the operation of carbonizing, under the most favorable conditions, always leaves the metal in a condition of almost absolute ruin, if no heat treatment were to follow the carbonizing. All carbonized steel before receiving heat treatment is brittle and also very soft, and its physical qualities are not as high as a poor grade of gray iron. The structure is coarsely crystalline throughout, with no definite division between the core and case and the whole structure seems to be lacking in cohesion, suggesting to the eye something that is just ready to fall apart of its own volition. A microscope reveals only a slight difference in the conditions visible to the unaided eye and shows that the structure of the case is a bit closer and somewhat finer grained. The lack of cohesion, however, is more pronounced when observed under the glass.

In order to make this metal of any value, it becomes necessary to subject it to heat treatment. If the highest quality is desired in the structure of the core, the heat treatment must be at such a temperature, and of such a nature as will place it in the condition found before the operation of carbonizing disturbed its structure. This means that the metal must be heated slightly beyond its critical temperature and quenched. If the highest quality is desired in the case also, the same treatment must be repeated for the higher carbon case.

It is sometimes the practice of casehardeners to quench steel directly from the pot at temperatures very close to the carbonizing temperature. While this sometimes is practiced without any serious results, it is bad practice and parts so treated never possess anything approximating the quality possible were they handled properly. Other casehardeners allow the parts to cool slowly in the pots and reheat for a single quench. In such cases, great economy is sometimes effected if the loss of parts through failure to pass final tests does not absorb all the saving of an extra quench.

Quenching from the pot may result in serious losses, as

will be seen in following paragraphs, and the single quench treatment may bring such a variety of troubles that it would take too much space to enumerate them; but if it must be done, the operator should know first, whether the core or the case is most essential to the value of the part; second, he should know approximately at least, the carbon content of both the case and the core; and his treatment should be based upon one or the other for there is no one temperature which can give maximum quality to both. In some cases it is a matter of getting pieces hard without reference to any special quality that the work must show, and in such cases it is of little use to give advice; but to the casehardener who

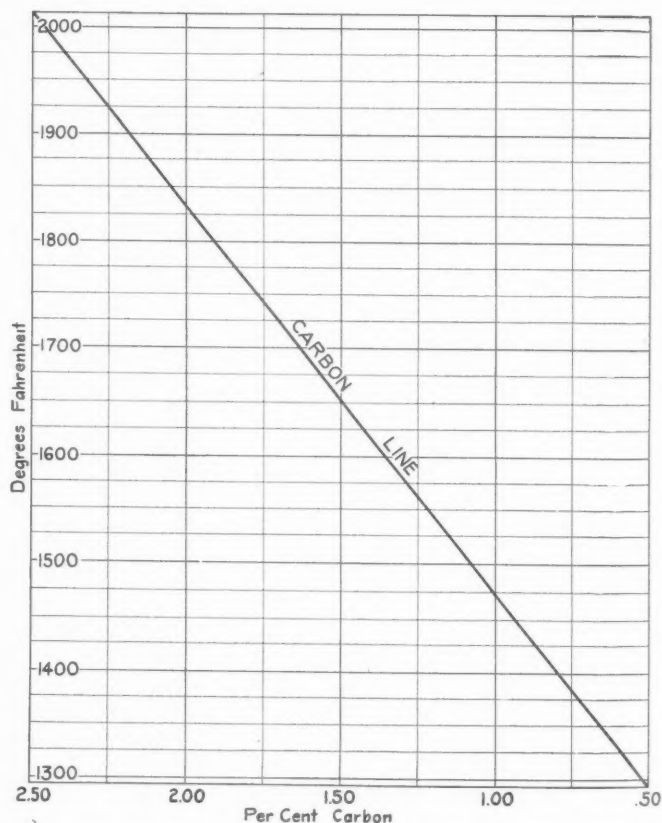


Fig. 1—Relation of Temperature to Carbon Content of Carbonized Case

has quality of work in his mind the writer suggests that he always make sure of every point, especially in the heat treatment of carbonized parts, for as shown, carbonizing itself absolutely ruins the structure of steel. Thus it is up to the steel treater to redeem it.

The effects of high temperatures, both in carbonizing and in heat-treating, are more marked in the quality of the case than in that of the core, because the core is always the same steel after carbonizing that it was before, and has the same critical point. The case, however, has assumed a different chemical constitution, different physical qualities, and has become a complex steel, instead of a simple, homogeneous metal that it was in the beginning. It requires a more exact knowledge of the constitution and physical qualities of the

*Abstracted with permission from the August transactions of the American Society for Steel Treating.

steel in order to determine the treatment it should have for its highest refinement.

Carbonized steel has often been referred to as a "double steel," because of the two zones of "low carbon" and "high carbon" set up in the carbonizing of the metal but it is more complex than a simple double steel, if we consider the conditions found in the chemical make-up of the case and the various physical conditions that are established in the application of heat thereto during the carbonizing as well as the heat treating operations.

It will be well to consider here something of the manner in which the case is made up and its true relation to the core. The carburization of steel is produced by the introduction of carbon into the metal from the surface toward the core. During this introduction of carbon that element is always more abundant at the extreme surface than it is at any point between the surface and the uncarbonized core; in other words, there is a gradual lessening of carbon content between surface and core, and no abrupt line of division between them. The percentage of carbon that will be present in the surface of the case depends most largely upon the carbonizing temperature to which the steel was subjected and partly, to the manner and nature of the heat treatment given it subsequent to carbonizing.

Relation of Temperature to Carbon Content

The chart, illustrated in Fig. 1 shows the relative amount of carbon that steel will absorb when carbonized at various temperatures. This chart is based upon the researches of David Flather, who in 1903 in a technical journal, stated that: "Iron, saturated with carbon at 700 deg. C. can contain only 0.50 per cent carbon; at 900 deg. C., 1.5 per cent carbon; at 1,100 deg. C., 2.50 per cent carbon." These values are given as for the saturation of the iron in the metal; that is, the iron at those temperatures can contain the percentage of carbon indicated. In the application of the carbonizing process the fact should be remembered that there is always a saturation of the metal on the extreme surface and that saturation is maintained as long as the temperature is maintained. From that saturated portion of the metal the carbon diffuses into the metal just as water will diffuse into wood when the surface of the wood has become saturated with it. In like manner does the carbon find its way into steel; and the saturation gives way to gradual diminution of carbon content as it approaches the core.

The chart in Fig. 1 is more easily understood by considering the theory that all carbon is dissolved at the surface of the steel in all carbonizing operations, and is not deposited from gases entering the metal.

Some of the phenomena observed in the manipulation of the process seem to point to some such condition existing at the surface of the metal, for if we take a piece of carbonized, low carbon steel from the carbonizing pot while it is at a carbonizing temperature, and quench it quickly enough to avoid any possible chance of the carbon burning out of the metal when it comes into contact with the air, and have the quenching medium a very fast one, such as brine or ice water, we find a concentration of carbon at the extreme surface greater than ever experienced in the cooling of the steel in the carbonizing mixture and reheating, or even in the ordinary quenching direct from the pots. The carbon is there as a solid solution which has not had an opportunity to diffuse into the metal, and it is always there in a percentage equal to the saturation point of the metal.

This saturation and diffusion of carbon is responsible for the great complexity of the case referred to; it establishes in the carbonized portion or case what are recognized as three zones of varying carburization. These are shown according to their carbon content as the hypo-eutectoid, eutectoid, and hyper-eutectoid. The first of these zones, hypo-eutectoid, is that containing the lowest percentage of carbon, and lies

next to the core; its carbon content is under 0.87 per cent; the next, or eutectoid zone, is that portion of the case lying next to the hypo-eutectoid, and contains 0.90 to 0.95 per cent carbon; while the hyper-eutectoid contains above 0.95 per cent of carbon. Thus carbonization at temperatures above 900 deg. C. (1562 deg. F.) is quite sure to give a hyper-eutectoid case, and lesser temperatures may provide a case of most any desired carbon content.

In practice it would be difficult to establish an exact schedule of temperatures for the various requirements in carbon content but if we carbonize at a certain temperature, for a certain depth at least, the case will have the amount of carbon the chart indicates. Such depth is sometimes so slight as to make it difficult to get a chemical analysis, but photomicrographs often prove such values in quite a convincing manner.

After steel has been carbonized its heat treatment must be governed by the nature of the service that it will be obliged to render. If a hyper-eutectoid case has been established and the requirement is for extreme hardness without the need of any particular toughness in the sharp edges or the lighter sections of the material, the quench for the case should be at the critical temperature of approximately 1.00 per cent carbon steel, without any subsequent draw; but if the wear to which the parts are to be subjected is abrasive in character such as gears, or dies, the parts should be given a draw of

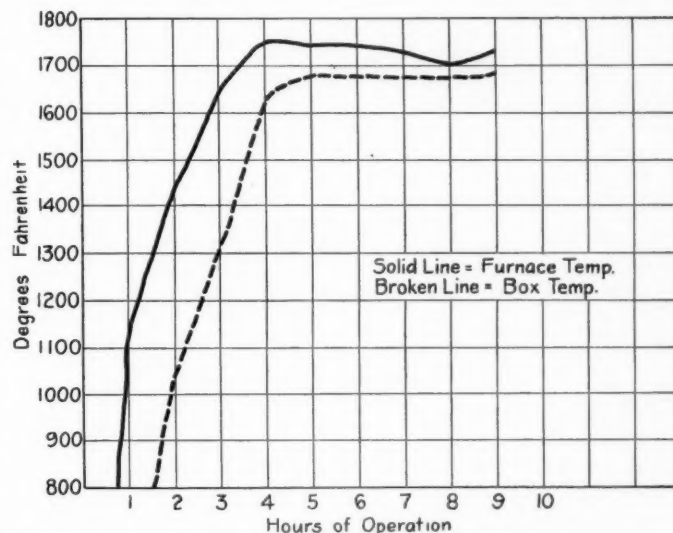


Fig. 2—Curves Showing Comparative Temperatures Inside and Outside of Boxes During Carbonizing Operations

approximately 400 deg. F.; the exact temperature of the draw can only be determined when the scleroscope or Brinell hardness requirement is known. It is a matter usually for the operator himself to determine by test, since there are always variations in steel, and in conditions within the shop that make it impossible to establish exact rules for hardening steel that may be followed successfully by all steel treaters.

A single quench for carbonized parts always should be avoided where it is economically possible, and never should be chanced where the carbonizing temperature exceeds 1,650 deg. F. (if quenching from the pot is necessary) for such practice results so often in the absolute loss of parts so treated, that the chance of avoiding trouble is too small to be worth considering.

Temperatures of Furnace and Carbonizing Boxes

A chart is shown in Fig. 2 giving the comparative temperatures inside and outside of carbonizing boxes during carbonizing operations; these are composite curves made from a long series of tests. This chart shows that under regular conditions the inside of carbonizing boxes is at a much lower temperature than that of the furnace.

There are conditions, however, when an excessive tempera-

ture is established inside of carbonizing boxes, and will increase there even after the temperature of the furnace has been lowered. One such test is shown in Fig. 3. In this case it will be noticed that the temperature inside of the box was higher than that of the furnace chamber for a period of more than $3\frac{1}{2}$ hours, and while the furnace temperature was falling rapidly, the box temperature was rising almost as rapidly. The cause of this condition was a very combustible carburizer made chiefly from coal products containing oil and other hydrocarbons, which produced gas at very low temperatures and at such velocity that the sealing of the box was of no use. Fig. 4 shows the result of another test of the same character, in which the trouble was not caused by the carburizer but by an imperfect box. In this case a small blow hole in the cast-iron box permitted the entrance of enough oxygen to stimulate the combustion of the organic matter of which the carburizer was composed. However, in the composite curve (Fig. 2) all of these various conditions are represented in the average indicated.

The writer does not wish it understood that he considers this composite curve a fair average of the conditions obtaining in general practice of the carbonizing process, for these tests were made under conditions which perhaps would not be considered the average, and under the best modern shop conditions a better result than this should be shown by

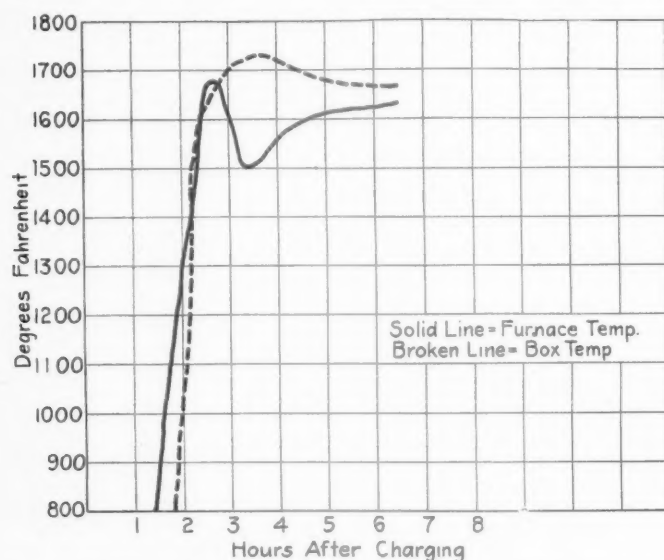


Fig. 3—Curves Showing Excessive Temperature Established Inside Carbonizing Boxes After Furnace Temperature Has Been Lowered

similar tests. The author believes that in the average case-hardening plant the operator is very much off in his estimate of the time required to bring carbonizing boxes to the temperature of the furnace, as indicated by his pyrometer, especially when little care is shown in the proper placing of the thermocouple. If some operators would take the pains to check up on themselves, they would meet some surprises. In these charts it will be noticed that the variation of temperature between the inside and outside of the boxes was very pronounced, sometimes for several hours, and the composite curve shows that as an average, there was a difference between the two temperatures of about 125 deg. after 4 hours of heat.

The boxes used in these tests were of standard size, of the following inside measurements: 4 in. wide, 6 in. deep and 18 in. long. Various kinds of carburizers were used to determine the comparative heat conductivity of the various compounds.

The relation of temperature to the quality of case and core is a very direct one, as indicated by the straight carbon line shown in the chart in Fig. 1. This is for the carbon content

of the case and should indicate to the operator the heat treatment of the case. In Fig. 5 is shown the quenching temperatures of steels of various carbon content, which will be useful to the operator who desires knowledge of the proper temperature for the refinement of the core or case. This chart does not take into consideration the presence of any alloying elements in the metal.

No Hard and Fast Rule for Heat Treatment

There are no hard and fast rules for the treatment of carbonized steel, beyond that of the strict observance of the

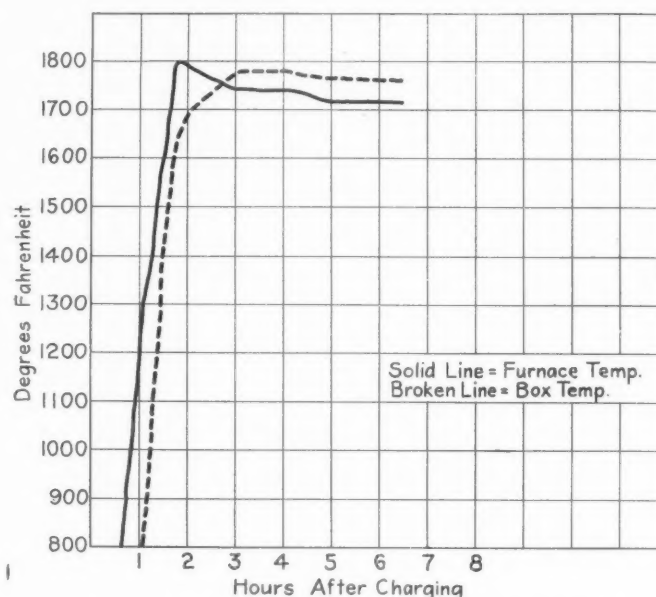


Fig. 4—Curves Showing Temperatures Inside and Outside of Carbonizing Box, the Box Being Imperfect

critical temperatures of the metal. This is at times difficult to determine without scientific apparatus for the purpose, and the average case-hardener can not avail himself of the use of those important and expensive instruments; so it becomes necessary for him to use common-sense, and proceed slowly in all his operations until they are demonstrated to be right. Where a critical point is in question, and no equipment for

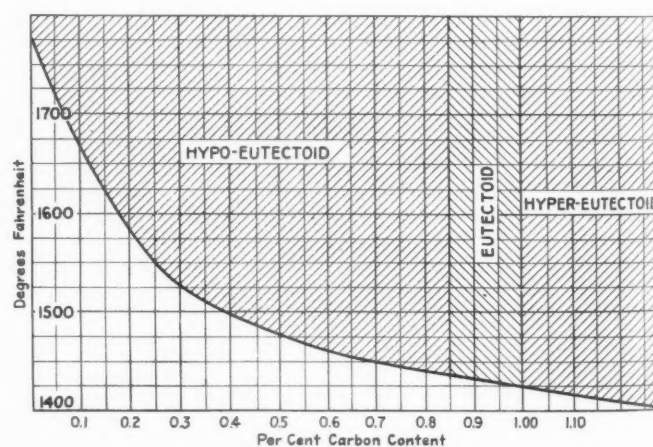


Fig. 5—Quenching Temperatures of Steels of Various Carbon Content

determining it is at hand, practical tests should be made until the fracture of the metal indicates the proper temperature. It is always better to sacrifice a few parts for the establishing of proper heat treatment than it is to go ahead blindly and perhaps sacrifice hundreds of valuable pieces later on.

Wheel Lathe Tool-Holders for Use With High-Speed Steel Tool Bits

THE day of the solid high-speed steel tool for wheel lathes has passed, owing to the excessive cost of the steel, difficulty in handling heavy tools and loss due to breakage. Several forms of tool-holders have been developed from time to time, using high-speed steel tool bits and thereby obtaining maximum service from the high-speed steel. Among these tool-holders, the two illustrated have been developed on a large eastern railroad and demonstrated their value by more than two years' continuous service. These tool-holders have several advantages over some of the other kinds developed. In the first place, the tool bits are solid pieces of high-speed steel made without holes. This is an important feature for two reasons: each tool bit can be readily heat treated with less danger of breaking than if it was drilled for a clamping bolt; in addition, when the tool bit is worn down as far as practicable in the tool-holder, it can be drawn out into smaller tool bits and thus entirely used up. This would be impossible had the tool bit been drilled.

In common with other tool-holders, the two illustrated

even necessary to loosen and retighten clamping bolts when removing the tool bits for grinding. They are readily released from the tool-holders without touching the clamping bolts and are just as easily replaced."

Holder for Round Nose Roughing Tool

Reference to Fig. 1 will show the general arrangement and details of the tool-holder and tool bit used in taking roughing cuts. This tool-holder is made of hammered axle steel in two styles, right and left, the details shown being for the left-hand holder. The body of the holder *A* is slotted at the right-hand end to receive tool bit *B*, which is shaped as indicated and carefully heat treated to stand up under the heaviest cuts. The tool bit is backed by a tapered wedge *C*, having teeth cut on the back as shown in the detailed view. Wedge *C* can be operated up and down for loosening or tightening the tool bit by means of a pinion on shaft *D* revolved by lever *E*. One end of *D* is supported by a bearing in *A* and the other end by sleeve *F*. The lateral play of *D* is also adjusted by sleeve *F*. Lever *E* fits on the squared

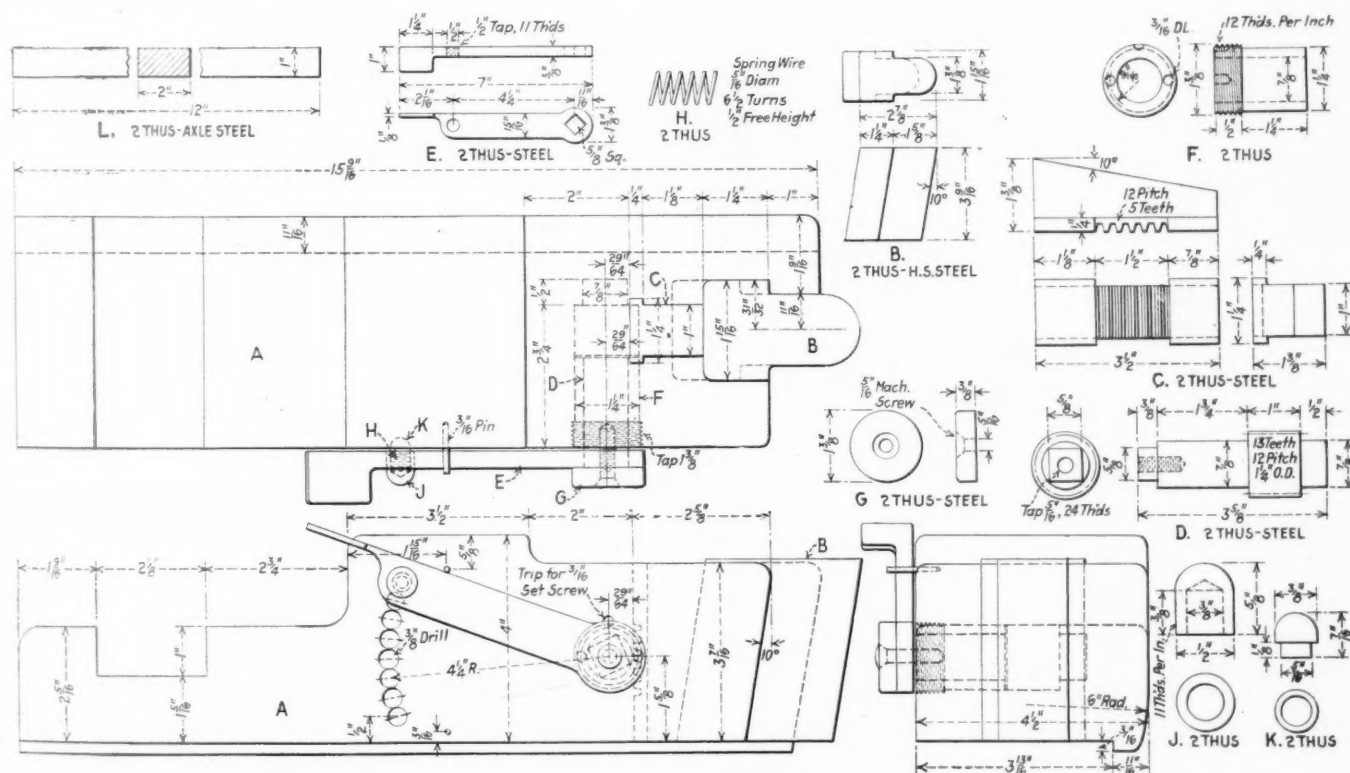


Fig. 1—General Arrangement and Details of Left-Hand Wheel Lathe Roughing Tool Holder

have the important advantage of greatly facilitating grinding. It is true that the roughing out of wheel lathe tools is commonly done in the toolroom on some form of tool grinding machine, but very often it is necessary for the wheel lathe operator to touch up the top surface of the tool at the cutting edge in order to secure the best results. It is something of an effort to carry a solid lathe tool 18 in. long, made of 1½ in. by 3 in. stock, to the grinding wheel and back again, to say nothing of manipulating it during the grinding operation. Moreover, unless two trips are made, both the right and left hand tool must be carried at the same time. As one lathe operator with many years' experience said, "These tool-holders are great time and labor savers. I get more work out of the machine and at less effort on my part by keeping the tool bits in first-class cutting condition. There are no more heavy tools to carry around and it is not

end of *D* and is held in place by means of a small washer *G* and a 5/16-in. machine screw. Parts *J*, *H* and *K* provide a spring button to enter the radial drilled holes in *A* and hold the lever in whatever position is desired. Stop pins, 3/16 in. in diameter, limit the swing of lever *E* as shown.

Should the tool post clamping bolts be insufficient to prevent the tool-holders from slipping back under heavy cuts, crossbar *L* is provided and can be inserted in the 2 7/8-in. by 1-in. slot in body *A*. With this crossbar held against suitable stops by auxiliary clamps, the tool-holder can be held rigidly under the heaviest cuts.

Holder for Finishing Tools

The general arrangement and details of a device for holding forming or finishing tool bits are shown in Fig. 2 and only one style of holder is required for both right and left-

hand tool bits. As in the previous case, the body *1* is made of hammered axle steel to the shape shown with one jaw indicated at *a*. Part *2*, shown in heavier lines, is a machined forging composed of jaw *b*, a circular body and a lever arm drilled and tapped for a 1 1/8-in. set screw *3*. This set screw extends through a 1 3/4-in. hole in body *1* and bottoms on the opposite side of the 2-in. slot shown. Tightening set screw *3* by means of a socket wrench will bring jaws *a* and *b* together and exert heavy pressure on forming tool *4*. Loosening the set screw will enable the forming tool to be quickly and easily removed. Forming tool *4* is provided for finishing the flange and part of the tread, tool *5* forming the remainder of the tread and the chamfer. In handling the tool-holder part *2* is prevented from falling out of body *1* by means of strap *6* held by two 5/16-in. fillister head screws *7*. This arrangement is plainly shown in the drawing. To facilitate machining part *2* a 15/16-in. hole is drilled as shown and this hole is later filled by driving in plug *8*. As in the previous case, the 2 1/2-in. by 1 3/16-in. slotted hole in body *1* is intended to provide auxiliary means for clamping the tool in place.

The construction of these tool-holders is such as to hold the tool bits and forming tools with great firmness under heavy cuts, at the same time permitting their ready removal for changing or grinding. When the tool bits are new, they

rest on the bottom against the wheel lathe tool post, but as they become worn down by grinding, filler blocks are inserted to keep the cutting edges at the required height. Reference to Fig. 3 shows the actual appearance of two tool-holders

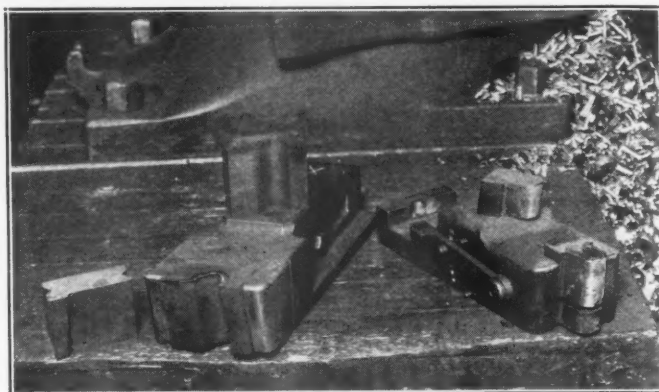


Fig. 3—Tool Holders, Tool Bits and Filling Blocks

which have just been removed from the lathe. Several tool bits, filling blocks and forming tools used with the holders also are shown.

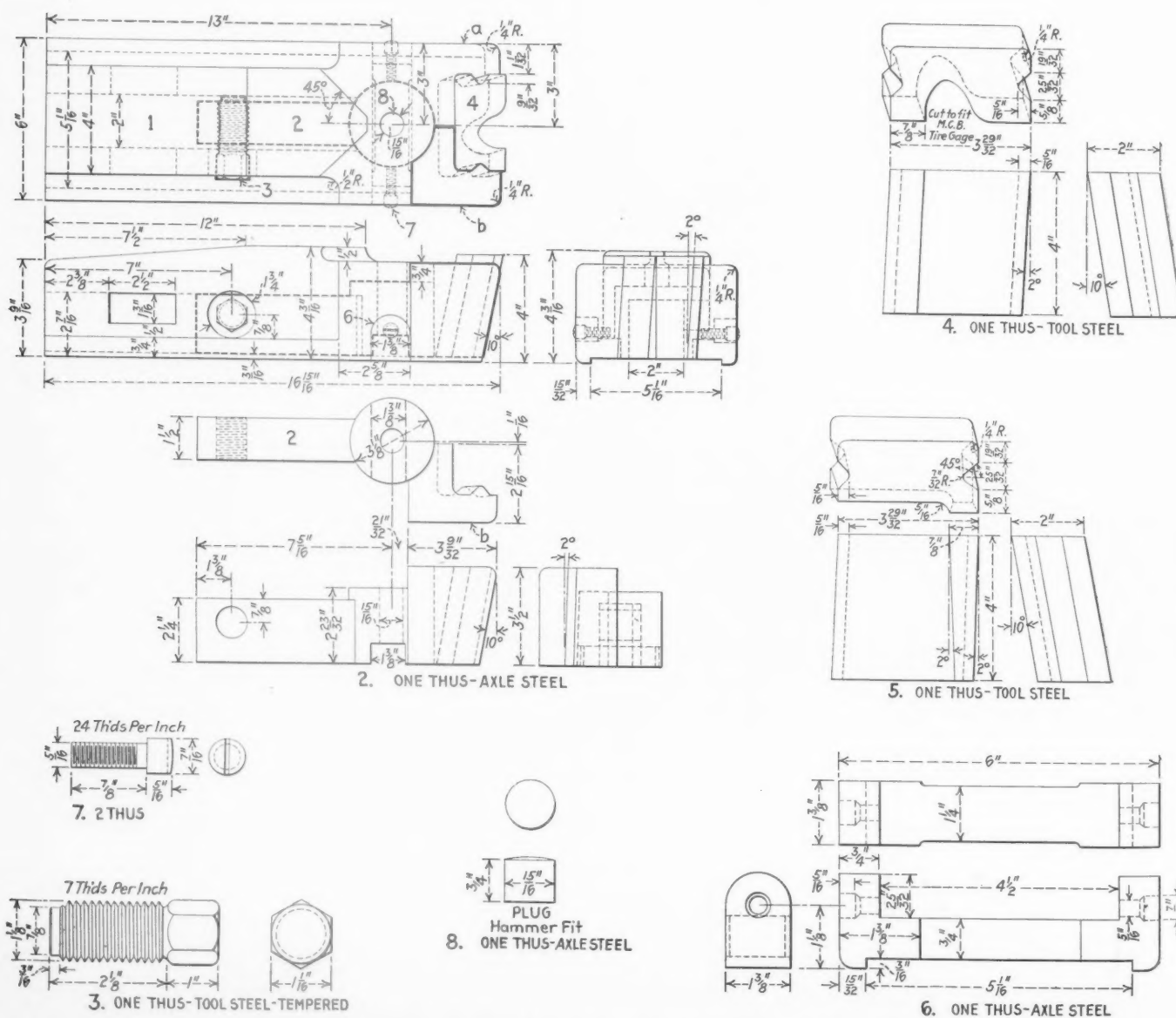
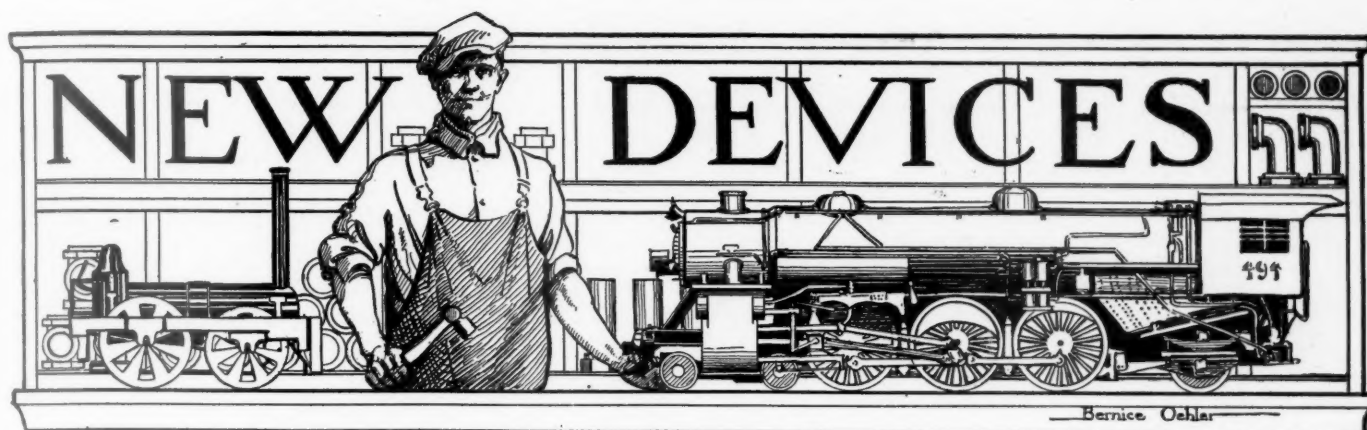
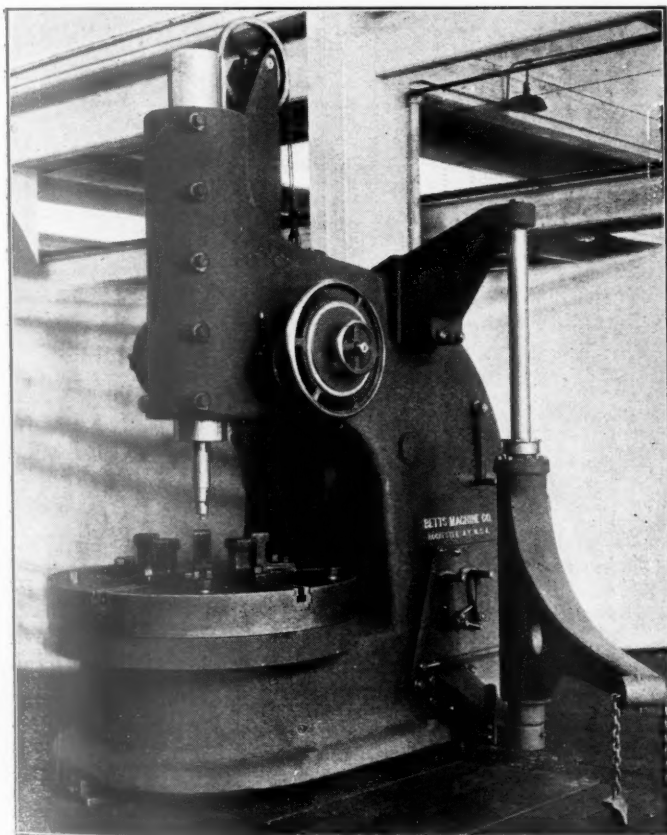


Fig. 2—Forming and Finishing Tool Holder, Made In One Style Only



Heavy Car Wheel Boring Machine

THE latest addition to the line of heavy railroad tools made by the Betts Machine Company, Rochester, N. Y., is a heavy duty, 52-in. car wheel boring and facing machine, illustrated. This machine is designed and constructed so as to cover the range of requirements of both manufacturing and repair shops, for car building and railway repair



Betts 52-In. Car Wheel Boring and Facing Machine

shop work, and is a rapid production machine for manufacturing purposes.

The bed and frame is one massive casting which is exceptionally rigid and the machine is designed to meet successfully the stresses of modern high production. While the design is massive and the construction heavy, special attention was given to extreme simplicity as well as ease of operation which in turn reflects itself in increased output.

The machine is furnished to be driven either through a

single pulley, or direct connected to a constant speed or variable speed motor. The necessary speed changes to give face plate revolutions of 10.2, 13.9, 20.4 and 30.7 per minute, are obtained by means of hardened sliding steel gears, running in oil. The two short levers shown on the photograph are used for obtaining the four speed changes and they are interlocked in such a way that no two sets of gears can be in mesh at the same time.

The table is proportionately heavy, revolves on a wide bearing and has an extra large spindle running in bronze bushed bearing. The spindle is provided with a locking collar at the lower end to prevent lifting and great care has been taken to insure proper and adequate lubrication for all revolving parts.

The table is equipped with a five-jaw chuck, built in and a part of the table. This chuck is both universal and independent, and readily adjustable for wheels of any size within the range of the machine. Five stations are provided for operating this chuck, so that one of them will be convenient to the operator regardless of where he stops the table. The long lever shown just at the right of the table is used for operating the friction clutch and brake, whereby the operator can start and stop the machine in the minimum time.

The boring ram is of large diameter, with an exceptionally long bearing in the frame. The six automatic boring and facing feeds are obtained by means of a two-step cone and triple hardened sliding steel gears, so arranged that change from roughing to finishing can be made instantly. The boring ram has an easy hand adjustment which is facilitated by a counterweight contained within the machine.

When so desired, this machine can be equipped with a facing ram which, however, does not show in the photograph. This ram is so constructed that the facing head is supported close to the cut, enabling much heavier cuts to be taken. Also it is so constructed that it can be slid back entirely out of the way when chucking the largest diameter wheels.

The machine is regularly equipped with a quick-acting, powerful, pneumatic crane for handling the wheels in and out of the machine. This crane can be furnished to operate by individual motor or belt if so desired.

A strong feature of this new design is the ease of control by the workman. Every lever, including the starting and stopping lever and the speed changing levers as well as the devices for changing feeds and the hand adjustment of the boring ram are within easy reach by the operator from one position and the friction clutch and brake provides a simple control that is most effective.

An Alloy for High Temperature Castings

THERMALLOY is a high chromium alloy said to remain unchanged under drastic thermal conditions. It is not affected at elevated temperatures by oxidizing or reducing conditions nor will it absorb carbon or other injurious substances.

Strength and freedom from internal changes and transformations under alternate heating and cooling are characteristics claimed for Thermalloy. These characteristics prevent bending, warping and cracking, so that containers made of this material retain their original form at high temperatures encountered in heat-treating operations. Tests have shown that the alloy will serve for several thousand hours at 1800 deg. F. and will give considerable life at 2300 deg. F. in intermittent service.

Castings made from Thermalloy are uniform and free from blow-holes or segregations and can be made from 1/16 in. up to any desired thickness and from an ounce or less in weight up to several thousand pounds. The alloy is easily welded or machined for special requirements.

PHYSICAL PROPERTIES

Melting point.....	2,760 deg. F.
Specific gravity.....	7.60
Weight per cu. in.....	0.27 lb.
Coefficient of expansion, per deg. F.....	0.0000088
Brinell hardness (1,000 kg.) (special grade, file hard).....	130-200
	Cast
Ultimate strength.....	60,000
Elastic limit.....	50,000
Elongation (2 in.).....	1.5%
Reduction of area.....	2.5%
	Forged
	120,000
	75,000
	10%
	15%

Curves showing the loss in weight by scaling of various metals are shown in Fig. 1. Test pieces of the indicated materials were obtained in the open market and after a careful determination of weight and surface area these were heated in a gas-fired furnace with excess air. At four-hour intervals the samples were removed, cooled, hammered free from

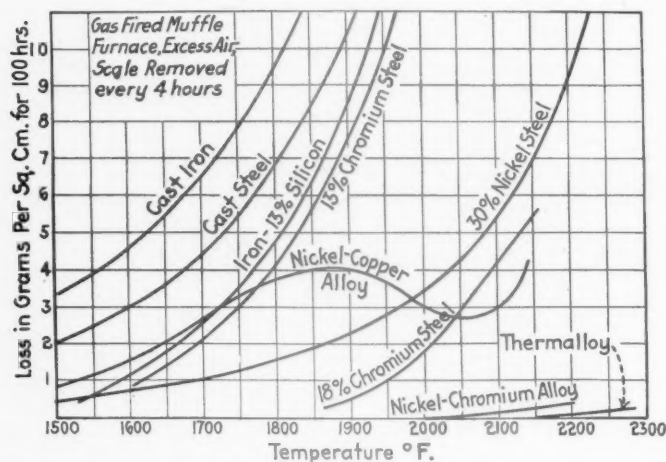


Fig. 1—Curves Representing Rate of Oxidation (Loss in Weight by Scaling) in Grams per Sq. Cm. per 100 Hr.

scale and then replaced in the furnace. At the end of each test period the total loss in weight was accurately determined and the loss per unit area calculated. This test was repeated at each of the temperatures indicated and the results so obtained are shown graphically in Fig. 1. The test shows that Thermalloy was entirely unoxidized below 2150 deg. F. and above this temperature more slowly affected than any other base metal at present available.

Next to oxidation heating efficiency is the most important quality of any material used for heat-treating work. Fig. 2 shows graphically the results obtained in a series of heat conductivity tests. Three new closed-end tubes exactly alike in dimensions—one of Thermalloy, one of steel and one of cast iron were placed cold in a furnace preheated to 2000

deg. F. Each tube contained a thermocouple which was mounted alike in all three. Temperature readings taken at ten-second intervals gave figures from which the curves A, B and C were drawn. These show that Thermalloy heats through more rapidly than new, unoxidized steel or cast iron.

The same three tubes were then heated to 1750 deg. F. for 100 hr. and the above test repeated with results shown by curves A' (Thermalloy unchanged), B' and C'. The interior of these three tubes reached 1500 deg. F. in 2 1/3 min., 3 1/2 min., 4 1/3 min., respectively. Five minutes after placing in the furnace the interior of the Thermalloy container had reached 1975 deg. F. while steel showed but 950 deg. F. and cast iron only 850 deg. F., an advantage of more than two to one.

The Thermalloy tube was later maintained for 500 hr. at 1800 deg. F. and the above test repeated on this tube alone

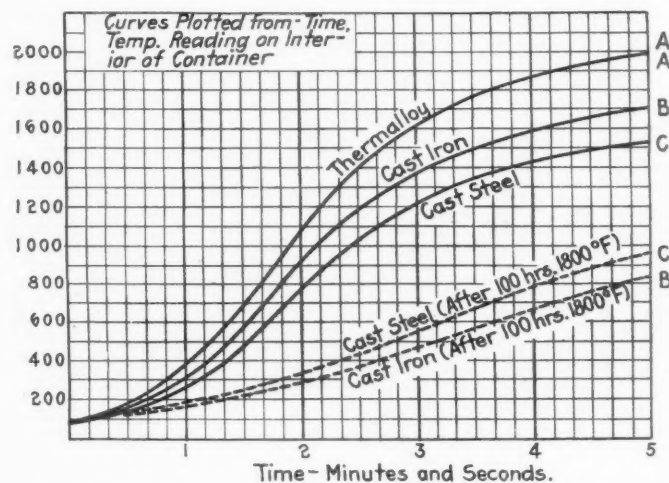


Fig. 2—Curves Showing Comparative Heating Efficiency of Thermalloy, Steel and Cast Iron and the Effect of Scale Formation on Heat Retardation

with identical results (the steel and cast-iron tubes were completely destroyed in less than 250 hr.) showing that the heating efficiency of Thermalloy is not affected by continued service.

The rate at which heat is transmitted to the interior of a metallic container depends primarily upon (1) wall thickness, (2) thermal conductivity of the metal, and (3) the condition of both inner and outer surfaces. Of these three factors surface condition is in this case by far the most important. As an example, cast iron or steel conducts heat over one hundred times more rapidly than does the oxide scale which forms on the surface of these same metals when heated, so that only 1/100 in. of scale will retard more heat than an additional whole inch thickness of scale-free metal. Also, a variation in this scale thickness from heat to heat will prevent uniformity of results.

Iron or steel boxes last only a few hundred hours, which means frequent replacements and often serious loss of valuable material, and this, together with increased fuel consumption and reduced furnace capacity due to greater weight and bulk and heavy scale, is often more expensive than the initial cost of a complete Thermalloy installation. Thermalloy is recommended for the following and similar high-temperature equipment: carbonizing containers, annealing boxes, lead, cyanide and salt pots, furnace grates, rails, doors and automatic stoker parts. Thermalloy is manufactured under Fahrenwald Patents (issued and pending) exclusively by the Electro Alloys Company, Cleveland, Ohio.

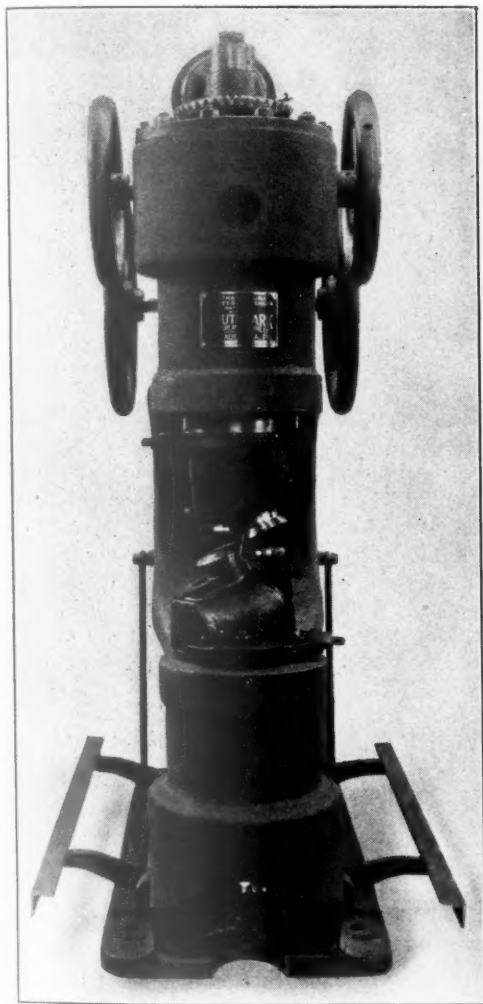
Rotary Turret Shear of Large Capacity

THE Southwark Foundry & Machine Company of Philadelphia, Pa., has recently developed a rotary shear, known as the No. 3 Southwark-Gray double turret rotary shear, which is capable of cutting plate up to $\frac{3}{8}$ in. in thickness and is therefore of a considerably larger capacity than the No. 0, No. 1 or No. 2 machines which were brought out a year ago. The No. 3 machine has a throat depth of 36 in. and is driven by a 3 hp. motor. The sizes and character of the work which can be done on this machine should make it a valuable tool for railroad shops.

Because the cutters, while working, can be changed to any degree of a circle, this machine shears various shapes without turning the sheet or plate during the cut. It cuts

shear cuts a straight line faster than any other tool except the gate shear, which makes the entire cut at one stroke.

The line to be cut is accurately followed by means of the turret, which is revolved by the guide wheel, the course of the cutters being changed to follow the line. On large sheets or plates, in making simple cuts, such as angles of any kind, the work can be done more quickly and easily by throwing the cutters in line with the cut to be made than by moving the stock in line with the cutters. When the position of the cutters is changed the direction of the feed is correspondingly changed. The cutters automatically feed the stock through the shear. The machine can be operated from either side so that the operator's vision of the



No. 3—Double Turret Rotary Shear—Both Turrets are Revolved Together so That Cutters Always Maintain the Same Relative Position

any conceivable shapes or openings with minimum radii equal to the radius of the cutters, in stock not heavier than one-half the capacity of the shear. On heavier stock up to the capacity of the machine the minimum radii will be slightly larger than the radius of the cutters. The cutters on this shear are smaller than on other rotary shears.

This shear cuts any shaped openings up to double the throat depth at any distance from the end of sheets or plates, regardless of length. Cuts as wide as the throat depth are made in a continuous operation. Greater widths up to double the throat depth are cut by first shearing in as far as possible from one edge. The sheet or plate is then given a half turn or is turned over and the balance of the cut is made from the opposite edge. The rotary

cutting line is never obstructed. When preferred the sheet or plate can be guided by hand, the same as on the old type shear.

It is never necessary to disengage the power and use hand power for small radii. The cutting of zigzag lines and small radii under power without speed changing gears is made possible by the sensitive clutch, by means of which the cutters can be started and stopped within a small fraction of an inch. While the cutting direction is being changed by the turret or by hand, a succession of pressures on the foot treadle controlling the clutch causes a corresponding stopping and starting of the cutters while the difficult cut is being made. Because it is thus possible to reduce the operating speed to a small proportion of the full cutting

speed, only one driving speed is necessary. In starting an inside cut, sufficient pressure is provided to force the cutters through the sheet or plate before the cut is started.

The adjustment of this shear is simple and positive. The horizontal and vertical adjustments of the cutters insure correct cutting edge without the cutters coming together and jamming. On small and medium sized work this shear is operated by one man. In shearing large sheets the operator and helper accomplish work formerly requiring several men. From 75 per cent to 95 per cent of the cutting heretofore done expensively only by tinner's shears, the acetylene torch or by punching or cold chiseling can be done quickly, accurately and economically on this shear. It saves the extra expense of cleaning up, such as filing, grinding, etc.,

that is necessary under former methods, because the turret rotary shear cuts a smooth, clean, square edge.

The turret makes possible a much wider range of work than has been possible on any other type of rotary shear. The lighter models cut parts for automobiles and general sheet metal, such as elbows, tees, hoods, disks, rings, etc. The heavier models shear plates used in building ships, locomotives, boilers, tanks, cars, bridges and structural plate work.

Since the turret makes possible the cutting of all shapes without extra space for swinging the sheet or plate while being sheared less floor space is required around the machine, and machines of smaller throat depth suffice for work formerly requiring a much larger shear.

Combination Hardness Testing Machine

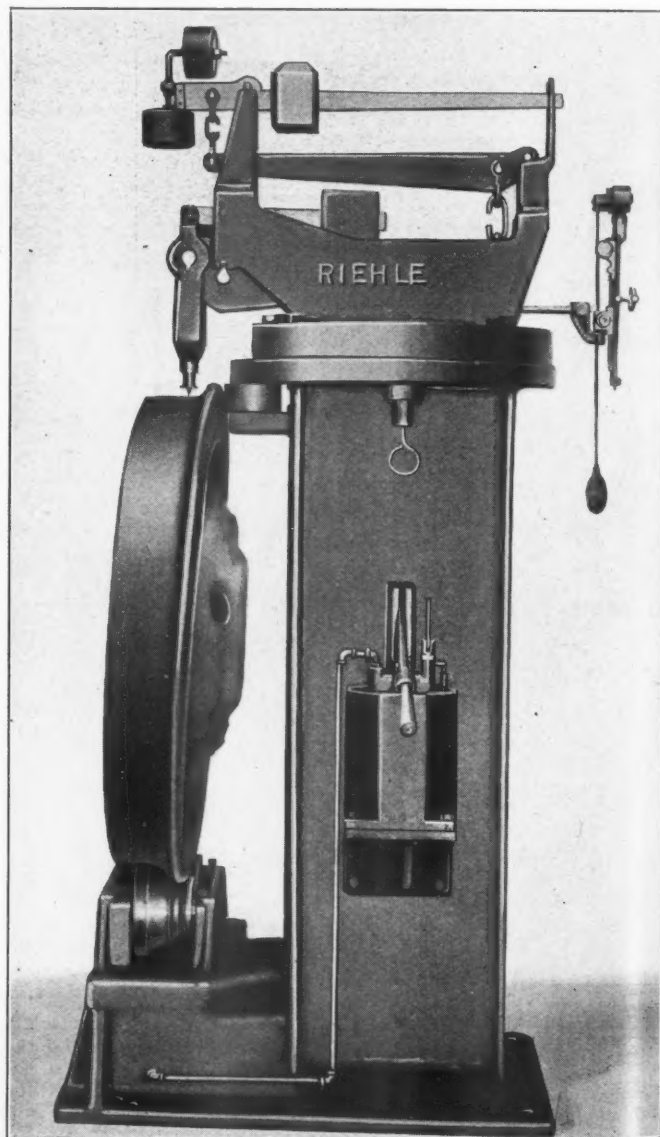
THE problem of making comparative Brinell and scleroscope hardness tests of identically the same spot of metal and on large size pieces is a difficult task where speed of operation and the number of tests made are considered. The Association of Manufacturers of Chilled Car Wheels determined upon an exhaustive study of the hardness of chilled wheels as compared to their wearing and breakage qualities. Tests were to be made to show whether any relationship existed between these properties and incidentally to determine the value of the hardness test as an indication of the general serviceability of the chilled iron wheel.

This study requires hardness tests by both the Brinell and scleroscope methods and on the same spot. No machine being available for this work, the problem was submitted to the Riehle Brothers Testing Machine Company of Philadelphia, and after several conferences with representatives of the association, the machine herewith shown was designed and built. The illustration shows a 33-in., 700-lb. car wheel in position ready for the Brinell test. The method of registering the Brinell load is the well-known Riehle lever and beam system which is considered more dependable than a hydraulic gage reading. At the rear of the machine is shown the familiar Shore scleroscope dart in the circumference of the same circle.

To test a wheel the turntable is revolved 90 deg. from the position shown and a car wheel rolled into place resting on the two grooved rollers. The turntable is now revolved until the scleroscope comes over the wheel. When the center position is reached a pin flies into a hole of the turntable and locks it. The scleroscope is now lowered by its rack onto the wheel and the test reading made. The scleroscope is raised, the pin withdrawn by the eye shown, the turntable revolved 180 deg. when the pin again locks it, and the ball is in position directly over the spot tested by the scleroscope ready for the Brinell test.

The rollers supporting the wheel rest on a hydraulic plunger and a few strokes of the hand pump shown raise the wheel against the ball. When the wheel touches the ball, an initial reading of the depth indicating device is taken. A few more strokes of the hand pump put on the full Brinell pressure which is indicated by the beam rising in the gage. A by-pass valve is momentarily opened, the wheel lowers slightly, a stroke or two of the hand pump again puts the wheel just in contact with the ball and another reading of the depth device taken. The difference between this and the first reading gives the actual depth of impression, even eliminating any flattening there may have been in the ball. The by-pass is again opened, the wheel lowers and the wheel is then revolved to a new position for testing. Thus a series of tests can be made around the wheel.

The depth indicating device mentioned is entirely new and rests in the Brinell head directly above the ball. Two fingers rest on the wheel while a third one rests on the ball. The relative motion of wheel and ball is thus registered without any intervening mechanism and the most accurate depth readings possible are obtained.



Brinell and Scleroscope Hardness Testing Machine

Boring, Drilling and Milling Machine

A NEW line of horizontal boring, drilling and milling machines has been developed by the Pawling & Harnischfeger Company, Milwaukee, Wis., of which the style 4-F machine, shown in Figs. 1 and 2, is the smallest size. This machine is especially designed for heavy milling and large boring operations and can be used either as a single-purpose machine or for general machine shop work.

The machine is modern in design, built to drive high-speed tool steels to capacity limits. There are numerous noteworthy features. Narrow guiding surfaces are used throughout; all feed screws are in tension and all sliding parts are arranged for taking up wear, the saddle is fully counterbalanced with the counterweight located inside the column. Centralized control is provided. All milling feeds

large revolving bronze worm wheel nut actuated by a quick-pitch worm on a quick-pitch steel screw. The motor is located at the base of the column.

The runway for the column is of rigid construction, very wide, of deep box section and heavily ribbed. All guiding members for the column, saddle and runway are of the square lock type with steel taper gibs to compensate for wear.

The spindle is of high carbon hammered alloy steel forging, ground to a sliding fit in its driving sleeve. The power is applied at the front end and the feed at the rear end through a rack and pinion. This construction provides the spindle with large bearings, front and rear, equally spaced at any point of its travel. The spindle is moved through its changes of feed by spur gears and positive clutches, actuated through a frictional worm wheel. The front end is bored for Morse taper and contains the necessary slots for driving milling cutters and boring bars. The drive is delivered to the spindle through a small face plate with a wide face coarse pitch gear or a larger face plate with internal gear of similar pitch and face. These face plates have slots and tapped holes for the attachment of milling cutters and facing heads.

The spindle-driving sleeve is of semi-steel and is ground to a taper fit in its bushing to compensate for wear. It contains adjustable bronze taper shoes for taking up wear due to the sliding of the spindle in the sleeve.

The drive is by constant speed motor, variable speed

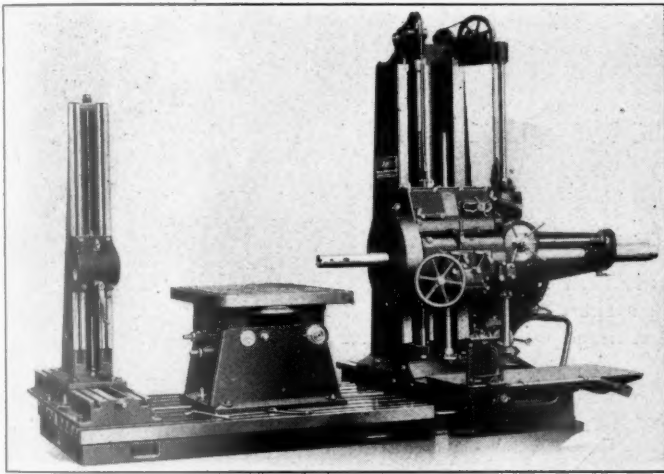


Fig. 1—Front View of Machine Showing Large Face Plate, Standard Spindle, Bed Plate and Outer Support

are actuated through quick pitch worm and bronze worm wheels, revolving on quick pitch screws in tension. Externally and internally driven face plates are interchangeable; back gears are close to the spindle, making all drive shafts high speed. Automatic stops are used for saddle and column for machines electrically driven.

The spindle-carrying saddle is of box section, well ribbed, and can be handled at any one point, when fully assembled, without fear of distortion. It contains the drive for the spindle, the feeding mechanism and the feed distributing mechanism. All drive gearing and shaft bearings are bronze bushed and the main spindle sleeve bushing is phosphor bronze, scraped to a slight taper for readily taking up wear of the spindle driving sleeve. The saddle is guided upon the column by a narrow guide placed at the front nearest the cutting pressure. The adjustment for wear is made by two steel taper gibs. The screw for feeding is in tension and is placed in the center of the guide. The saddle is fully counterbalanced, the steel cables being placed in the line of the center of gravity. The saddle is raised or lowered on the column by a revolving bronze worm wheel nut actuated by a quick-pitch worm, on a quick-pitch steel screw, either by hand wheel, power feed, or quick traverse.

The column is of heavy box section construction with two sides straight and two sides tapering to a long, wide base cast integral with it. It is guided by long narrow guides placed at the front and near the cutting pressure. The adjustment for wear is made by two steel taper gibs. The screw for feeding the column is in tension and is placed near the guide. The column can be traversed in either direction on its runway by hand wheel, power feed or rapid traverse from the saddle. These movements are through a

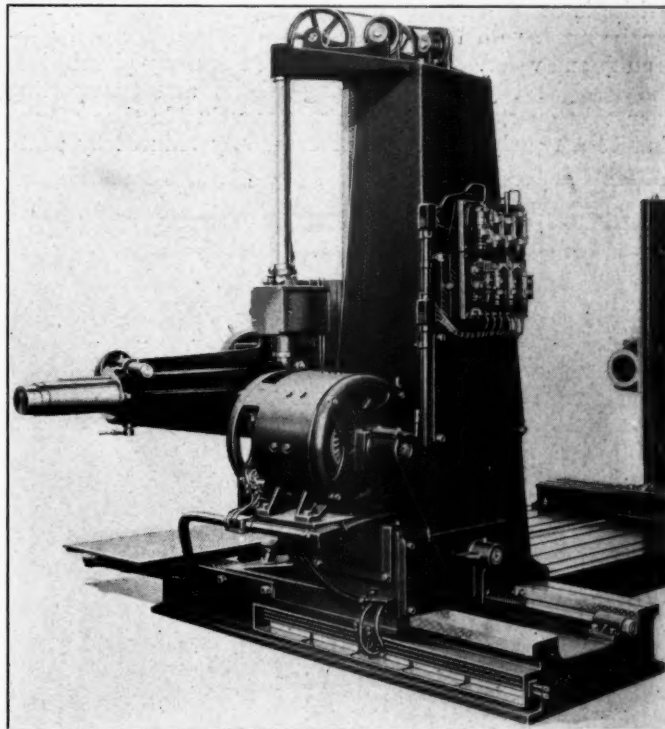


Fig. 2—Rear View Showing Sturdiness of Column and Motor Drive

motor, or belt. The motor is mounted at the base of the column (10 hp. capacity), and with direct current a two to one variation can be used. The machine is double back geared and by three levers 18 spindle speeds, in either direction are obtained. These spindle speeds are in geometrical progression and range from $5\frac{1}{2}$ to 200 r. p. m. The gears are of special alloy steel, with coarse pitch and wide face.

The boring and drilling feeds to the spindle are eight in number, reversible, and range from 0.0076 in. to 0.45 in. per revolution of spindle. The milling feeds to column

and saddle are eight in number, reversible and range from 0.009 in. to 0.54 in. per revolution of spindle. These feeds are driving direct from the spindle, back geared and in geometrical progression with no idle gears in mesh. The feed gears and shafts are of alloy steel. Rapid power traverse independent of feeds is transmitted to the saddle and column at a constant speed of 60 in. per min.

All operating levers and hand wheels are within easy reach of the operator and conveniently arranged for the operations required. The starting, stopping, reversing and changing of feeds or speeds, fast or slow, by hand or power, are controlled by the operator on the platform attached to the column. The movements of all levers are interlocking, it being impossible to have any two conflicting speeds or feeds in action at the same time.

The work bed is provided with planed T-slots running parallel to spindle travel. Three sides have a planed squaring stop for alining work. This work bed can be made to any desired size. The outer support, unless otherwise

specified, is made with 48 in. vertical and 48 in. horizontal traverse and is adapted for supporting boring bars. Graduated steel scales for the main column and saddle, also the outer support saddle and column, are furnished, reading to 1-1000 in. by use of the verniers. A screw chasing attachment can be furnished to cut threads, varying from 2 to 16 threads per inch and to any length within the capacity of the machine. A universal tilting and revolving table, or a plain revolving table, with movement by hand or power, can also be furnished if the machine is to be used on work requiring such attachments.

The diameter of the spindle is 4 in. and a No. 6 Morse taper hole is provided in the spindle. The feed of the spindle is 36 in. (more if desired by slipping); the vertical travel of spindle saddle, 48 in.; the horizontal travel of column, 48 in. (more if desired in 24 in. additional lengths); the minimum height of spindle from 9-in. bed plate, 25½ in., and the maximum height of spindle from 9 in. bed plate, 73½ in.

Locomotive Driving Wheel Quartering Gage

SIMPLICITY of construction and use are two outstanding features of a new locomotive driving wheel quartering gage, recently placed on the market by the Ashton Valve Company, Boston, Mass. The gage has been designed for use in railroad shops and enginehouses where a quick and accurate means of testing out reported crank-pin irregularities is desired, the reliability and speed with which tests can be made with the gage being strong evidence of its ingenuity and value. The present method of using plumb lines and straight edges, or removing wheels and transporting them to a quartering machine, wastes valuable time of mechanics and helpers which can be greatly reduced by using

can be taken which will accurately indicate whether the wheel is in the proper position, and if not the necessary amount that it should be moved before being pressed fully on. The quickness with which this operation can be performed will, in a short time, save the initial cost of the gage.

The gage is illustrated in Fig. 1 and its method of use in

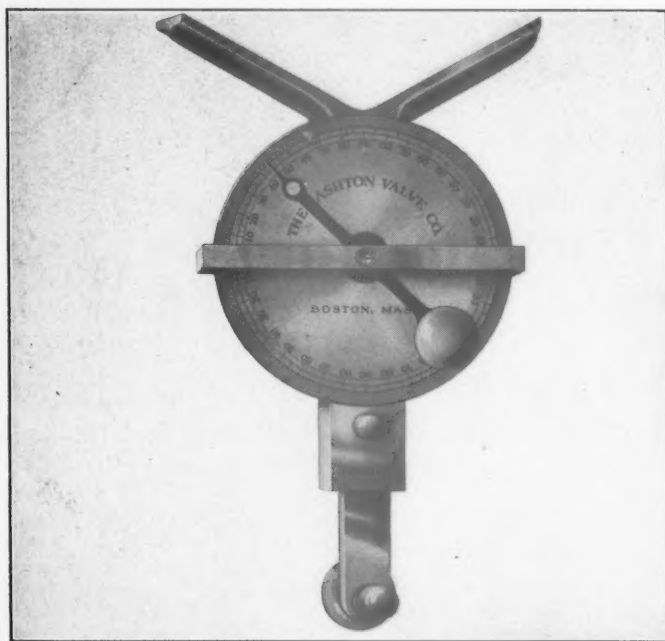


Fig. 1.—General View of Ashton Driving Wheel Quartering Gage

the new gage. A mechanic can readily test pins for quartering in any position of the drivers without removing them from the frames, requiring but a few minutes per pair of wheels, whereas the old method takes a mechanic and helper several hours. The gage is likewise a time-saver when applying new axles to old wheel centers. By pressing one wheel on its axle and then starting the opposite wheel, gage readings

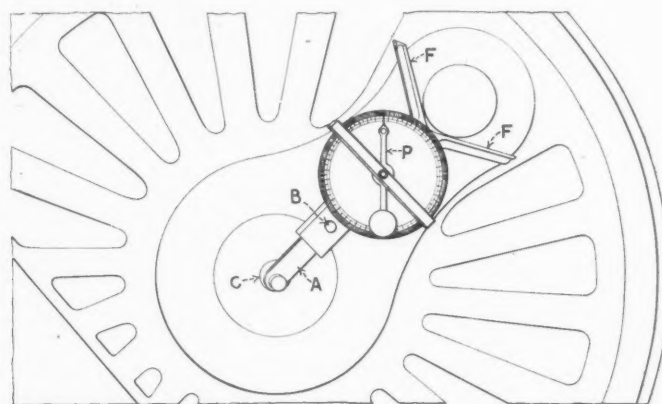


Fig. 2.—View Showing Method of Using Quartering Gage

Fig. 2. It is made to accommodate 24 to 32-in. stroke locomotives, being provided with an adjustable arm *A* (Fig. 2), being held in any desired position by thumb screw *B* and having a ball center *C* at one end for application in the center hole of the driving axle. After *C* is fitted in place the angle end of the gage is raised until the arms *F F* meet the crank-pin. A reading is then taken of the position of pointer *P* on the dial. Pointer *P* is gravity operated by means of the circular weight on the lower end and revolves entirely about the circumference of the dial, sufficient space being provided for the weight to pass between the cross-bar and the graduated dial. The pointer axis is set on hardened steel pivot points and is, therefore, practically frictionless. The weight on the end of the pointer is sufficient to cause the pointer to oscillate and assume an accurate vertical position.

In operation, readings are taken with the gage first on one driving wheel and then on the opposite wheel. If the sum of the two readings is more or less than 90 deg. it shows that the crank-pins are out of quarter and a change of wheel setting is needed. For instance, should the reading be 44 deg. on one side and 47 deg. on the other, or a total of 91 deg., the pins are out of quarter one degree which, on a 24 in. stroke

engine, is equivalent to $15/64$ in. Each gage is made of bronze, carefully finished and provided with a substantial box to protect it from injury. With each gage a scale is

provided showing the fractions of an inch corresponding to one degree of crank-pin angular variation on 24 in. to 32 in. stroke locomotives. The total weight of the gage is $9\frac{1}{2}$ lb.

Oil-Pressure Transmission and Feed Control

ENABLING a machine tool operator to work heavy carriages and rams quickly and without physical effort is one of the advantages of the Oilgear feed control developed by the Oilgear Company, Milwaukee, Wis. This control allows the operator readily to increase the feeds when cuts become lighter, back out the tool for observing the cutting

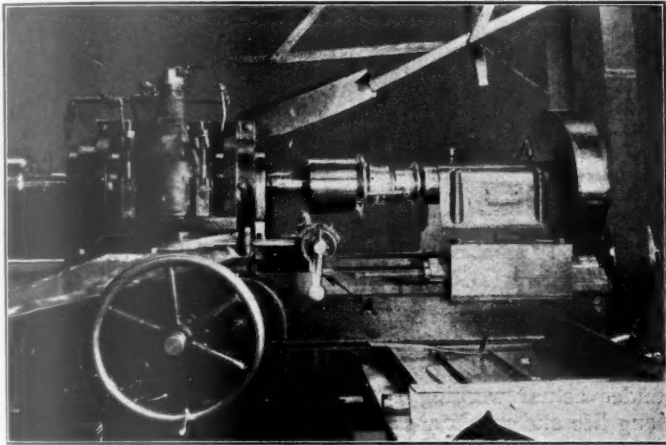


Fig. 1—Front View of Heavy Two-Head Boring, Facing and Tapping Lathe Equipped with Oilgear Feed Control

edge, and return it at will. It also makes it possible to use two or three different feeds in quick succession, when the cuts only last a short time.

In many cases the improvement to be effected justifies an installation on machine tools already in operation. Such a

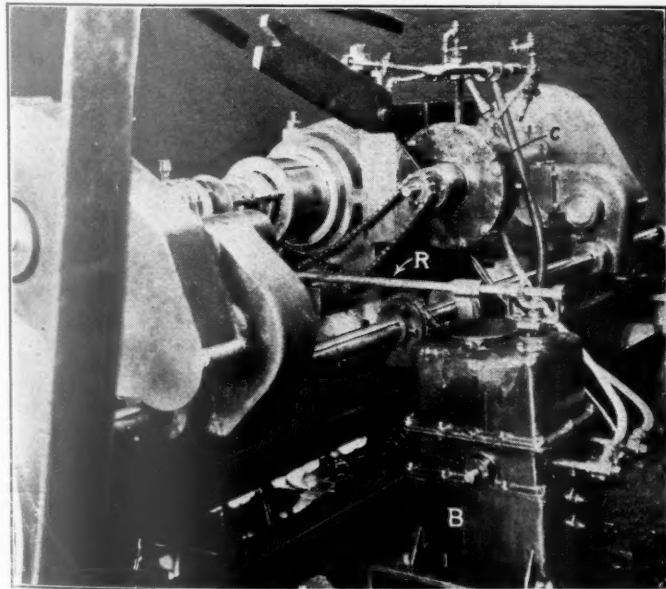


Fig. 2—Rear View of Lathe Shown in Fig. 1

case is the double-headed boring and tapping lathe (Fig. 1) which shows the control handle *A* within easy reach of the operator. Fig. 2 shows the Oilgear feed controller *B* and motor *C* installed at the rear of the lathe, with feed control rod *R* extending through to the front. Before this installation was made, the operator had to turn the large hand wheel

more than 70 turns, requiring more than one-half minute of hard work in every eight-minute period, in order to back out the tools and place a new casting in the jig. In addition, the facing cut had to be fed by hand as the existing feeds were not suitable. It is stated that in this case the speeding up of rapid traverse and the economies due to correct feeds and greater convenience of manipulation, made possible a total increase in production of 25 per cent.

Delivery of fluid from the feed controller, varied in quantity and direction, compels the feeding motor to perform exactly the function desired by the operator. The pressure in the system is large or small according to the resistance offered to the cutting tool, but the feed motor moves at the exact rate of speed called for by the operator, without regard to the pressure which it must exert to do the work. If this pressure rises above the maximum required for feeding, a relief valve

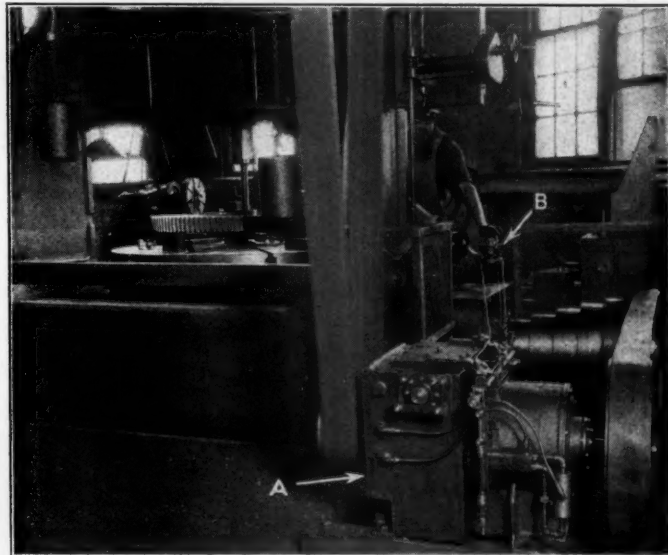


Fig. 3—Rear View of 7-Ft. Boring Mill Equipped with Oilgear Variable Speed Drive

opens and permits the feed motor to come to a standstill without damage. This function is made use of in locating shoulders, etc., in work to be machined, as it is only necessary to set rigid stops and let the carriage run against them as desired.

The same functions of variable speed, rapid traverse, accurate control, etc., make the Oilgear system valuable for planer drive or hydraulic press operation.

Variable Speed Drive for Machine Tool Spindles

The Oilgear Company has also developed a larger type of machine designed to drive the spindles of machine tools at any desired speed, from line shaft, constant speed electric motor, or gasoline engine. The unit, shown at *A*, Fig. 3, is of about 10 hp. capacity, designed for driving lathes, boring and milling machines, etc. The principle of operation is similar to that of the feed control system, securing for the operator an infinite number of speed changes in either direction through the manipulation of one single control handle. These functions and speeds selected by the operator are obtained irrespective of changes in load unless the load becomes excessive in which case an automatic overload gear

relieves the operator of responsibility by preventing him from overloading the machine. The overload gear may be adjusted to any desired maximum load up to the capacity of the

machine. When this is exceeded, the speed will be reduced, even to stopping the tool entirely in case of a jam. The control valve is located at B, Fig. 3.

Combination Fibre and Metallic Packing

AN unusual and interesting rod packing, said to combine the adjustment features of non-metallic packing with the wear-resisting qualities of metallic ring packing, is V-Pilot Packing, made by Pilot Packing Company, Inc., Chicago. The packing takes its name from the patented contour of the metal which is shaped like a "V" to insure an entirely metallic surface on the rod at the slightest pressure of the gland. The face of the metal, as shown in Fig. 1, is

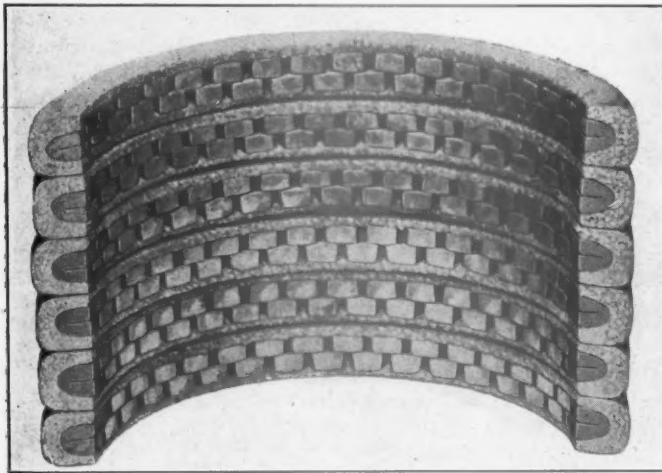


Fig. 1—Cross Section of a Set of "V" Pilot Packing

slotted, the slots being staggered to prevent the escape of steam down the rod. The slots serve another useful purpose by retaining oil for the lubrication of the rod. A hasty glance at Fig. 1 may give the impression that there are two pieces

of metal instead of one, but on closer examination the V-shape of the solid, white metal bar is apparent.

"V" Pilot Packing has a resilient, pliable back, fitting it for many uses for which purely metallic packing is not

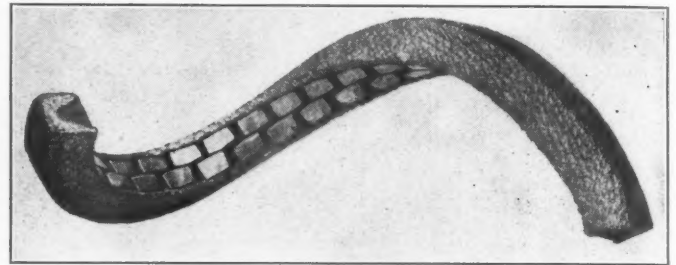


Fig. 2—View Showing Flexibility of New Packing

adapted. Its extreme flexibility, as shown in Fig. 2, permits its use on small rods and provides easy and quick adjustment. This packing has successfully passed the experimental stage and demonstrated its value by extended tests under actual working conditions, having shown unusually long life and resultant economy. It has a wide range of application and is used by railroads for air pumps, boiler feed pumps (steam and water ends), valve stems, throttle stems, power reverse gear rods, stationary air compressors, steam engines, hot and cold water pumps, ammonia pumps, round-house washout pumps, power plant feed water pumps, pumping station (steam or water glands), steam hammers and many other purposes. "V" Pilot Packing is supplied boxed and ready for immediate service and is applied in the same manner as ordinary fibrous packing.

A New Precision Machine Alining Level

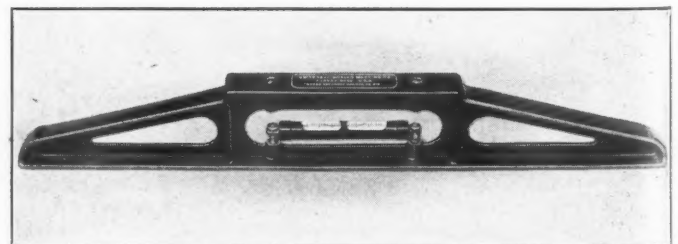
THE Universal Boring Machine Company, Hudson, Mass., has just placed on the market a precision machine alining level which is different both in design and construction from previous precision levels. The frame is of cast iron, truss construction, of sufficient strength to eliminate strain and the length of the levelling surface is 27 in.

The vial used is made of Jena glass, especially ground, and is filled and guaranteed by a prominent level maker. The vial is set in a brass japanned case which in turn is mounted on two lacquered brass studs, one at each end. After adjustment, the vial is locked by two nuts working against each other. The adjustment also has a cross travel. This ensures all adjustments similar to those on the finest surveying instruments. The bubble in the vial has a sensitivity of 5 sec. of arc per graduation, equivalent to 0.0002908 in. per ft. The vial is carried in such a manner that protection from breakage is assured.

The level casting is thoroughly insulated from the palm of the hand by means of a handle of non-conductive material and consequently distortion from this source is completely eliminated.

In constructing the level the casting is first planed and drilled and allowed to thoroughly season. After the metal

has proved its season, the base is hand scraped and tested. It is then allowed to rest for a period and is tested again. The vial is then adjusted. The instrument is furnished



Level Designed for Accurate Work

with a case and is equipped with a strong brass handle thus enabling it to be conveniently carried by service men on the road. The weight is 9¾ lbs.

SEVENTY-FOOT mail storage cars having become common, the Postmaster General and the Railway Mail Pay Committee have petitioned the Interstate Commerce Commission to approve the use of such cars at a pro rata increase over the rate for 60-foot cars.

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Subscriptions, including the eight daily editions of the Railway Age, published in June, in connection with the annual convention of the American Railway Association, Mechanical Division, payable in advance and postage free: United States, Canada and Mexico, \$3.00 a year; elsewhere \$4.00, or £1 0s. 0d. a year. Foreign subscriptions may be paid through our London office, 34 Victoria street, S. W. 1, in £ s. d. Single copy, 35 cents.

WE GUARANTEE, that of this issue, 7,800 copies were printed; that of these 7,800 copies, 7,080 were mailed to regular paid subscribers, 10 were provided for counter and news company sales, 235 were mailed to advertisers, 8 were mailed to employees and correspondents, and 467 were provided for new subscriptions, samples, copies lost in the mail and office use; that the total copies printed this year to date were 92,850, an average of 9,285 copies a month.

The Railway Mechanical Engineer is a member of the Associated Business Papers (A. B. P.) and the Audit Bureau of Circulations (A. B. C.)

The American Railway Association now has a Safety Section in the Operating Division, with a temporary Committee of Direction.

The Interstate Car Company, Indianapolis, Ind., will build an addition to its foundry in that city, 91 by 126 ft., at an approximate cost of \$25,000.

A fire in the roundhouse and local shops of the Erie Railroad at Jersey City, N. J., on September 11, destroyed one building, partly destroyed another one and damaged 18 locomotives; estimated total loss \$100,000.

The New York, New Haven & Hartford has bought from the International Motor Company three gasoline motor cars, supported by special trucks, with seating capacity of 35, also compartment for baggage. Delivery of these cars is expected early in December and they will be used in short haul passenger service on branch lines.

Edgar E. Clark, formerly chairman of the Interstate Commerce Commission, and Wilbur La Roe, Jr., have formed a partnership under the firm name of Clark and La Roe for the handling of matters before the agencies of the government, including the committees of Congress. Their offices will be in the American National Bank Building, Washington, D. C.

London to Birmingham in two hours is the time advertised for the best trains in the latest time-tables of both the London & North Western and the Great Western Railways. This is the first restoration of these fast schedules, which were discontinued during the war. The distance between the two cities, by the North Western, is 113 miles, and by the Great Western, 110 miles.

Trains on time (passenger trains) on the Pennsylvania Railroad in July numbered 94.2 per cent of the total passenger trains operated; and 96.8 per cent made schedule time. This is an improvement of 16.8 per cent and 9.0 per cent respectively over the figures for March, 1920, the first month after the property was returned to the Pennsylvania management. Engine failures and car failures have been reduced.

C. L. Bardo, general manager of the New York, New Haven & Hartford, on September 5, sent out a notice to all employees advising that not one employee had been killed during the month of August, and congratulating them on their successful adherence to "safety first" in their work. Once before—in May, 1920—a similar record was made. This road operates about 2,000 miles of lines with about 1,200 locomotives.

The question of resuming hearings in the general railway investigation before the Senate committee on interstate com-

merce has been postponed, to be decided at a meeting of the committee following the Congressional recess. There is some sentiment in the committee for discontinuing the hearings, but strong pressure is being brought by others to hear testimony from the labor and other interests not represented at the hearings so far.

Veteran Employees' Associations are being organized on all divisions of the Pennsylvania Railroad, which have not already organized, and campaigns are going on to increase the membership of those associations already in existence. As soon as the divisional organizations are perfected it is planned to hold a Pennsylvania System convention. Approximately 38,778 employees are eligible for membership in these associations by virtue of 20 years of service; that is, one employee in five. Many of the 6,185 former employees now on the pension roll are members of the division veterans' association. These associations were first started in 1897, and they have been among the active factors in perpetuating those traditions and ideals of public service and mutual co-operation between officers and men which have been handed down through 75 years of Pennsylvania Railroad history.

Seven new rules, recognizing and continuing the principle of punitive pay for overtime work in railroad shops, have been promulgated by the Railroad Labor Board as the solution of one of the stumbling blocks in the negotiation of new agreements regarding rules and working conditions between many railroads and their shop employees. These new rules, which are effective as of August 16 and are retroactive to July 1, also recognize and sanction the principle of the eight-hour day, the policy of paying time and one-half for work performed on Sundays and holidays except that work which is absolutely essential to continuous operation and the practice of paying an allowance to an employee called but not required to work. On the other hand, the provisions of the seven new rules so change the overtime rules in the Shop Crafts Agreement that several of the wasteful effects brought to the attention of the Board during the hearings on national agreements will not be continued.

Study of Wood Seasoning

The Forest Products Laboratory, Madison, Wis., in co-operation with saw-mills and wood utilization plants throughout the country, is organizing an extensive field study of the air seasoning of wood. The purpose is to determine the piling practice which will result in the fastest drying rates consistent with the least depreciation of stock, the least amount of yard space required and the least handling costs. All the important commercial woods of the United States will receive consideration. The study of both hard and soft woods will be

carried on concurrently. This investigation will furnish a comparison of the effects of such piling variables as the spacings of boards in layers, the height of pile foundations, and the directions of piling with relation to prevailing winds and yard alleyways. It is expected that the study will determine whether lumber should be dried partly at the mill and partly at the plant of utilization or whether it should be dried completely at the mill. Data collected are expected also to show whether air seasoning or kiln drying is more economical.

Ohio Man Appointed American Purchasing Agent for Chinese Government

Charles H. Kettenring, president of the Defiance Machine Works, Defiance, Ohio, has been appointed purchasing agent in America for the republic of China. Mr. Kettenring will have charge of purchases in this country of practically all classes of equipment and supplies of a mechanical or engineering nature.

New Zealand's Premier Favors British Manufacturers

W. F. Massey, prime minister of New Zealand, speaking at Darlington, England, is quoted by the Times (London) Trade Supplement as saying that in his dominion British goods are now given preference and that he hopes that more can be done in that direction in the next few months. He states further that New Zealand is coming to Britain soon to place orders for 2,500 freight cars, 45 locomotives and a quantity of rails.

Purchasing Department Changes on Japanese Government Railways

The financial and purchasing department of the Japanese Government Railways has organized a new section for the purpose of making extensive purchases of modern labor-saving machinery for the mechanical and engineering departments. This section, which will be under the direction of Shinji Sogo, will also arrange for the purchase and installation of modern equipment for the railway's offices.

Anthracite Shipments, August, 1921

Shipments of anthracite for August, as reported to the Anthracite Bureau of Information, Philadelphia, amounted to 5,575,115 gross tons, as compared with 5,462,760 tons in the preceding month, and with 6,207,653 tons in August, 1920. The decrease from August, 1920, was due chiefly to continued light demand for all sizes except stove, and to a continuance of scattered colliery suspensions caused by market conditions and petty strikes.

Implement Manufacturers Urge Abrogation of All Labor Agreements

W. H. Stackhouse, president of the National Implement and Vehicle Association, has issued a statement setting forth the association's ideas regarding the railroad labor problem. Mr. Stackhouse urges as imperative that the "iniquitous Adamson law" be repealed, and, in addition, that the Labor Board be directed "to abrogate all labor agreements, including the unionization of our great transportation system."

150 Cars, Eleven Miles an Hour

On August 7, the Ann Arbor Railroad ran what is said to be the longest freight train ever operated in the State of Michigan. It was from Owosso, Mich., southward to Toledo, Ohio 104 miles. The train left Owosso at 6:15 a. m., with 53 loads and 97 empties, weighing 3,932 tons, and arrived at Toledo at 4:00 p. m., with 53 loads and 98 empties, weighing 3,951 tons. It was hauled by one locomotive of the Santa Fe type with 70,000-lb. tractive effort, equipped with duplex stokers, except that a pusher was used for four miles out of Owosso.

Tentative Consolidation Plan

A tentative plan for the consolidation of the railway properties of the continental United States into 19 systems with one alternative plan for the New England lines, was made public by the Interstate Commerce Commission on Wednesday, September 28, and served upon the railroads and state authorities as the basis for a plan to be ultimately adopted by the commission, in accordance with the provisions of paragraphs 4 and 5 of Section 5 of the interstate commerce act, after public hearings, the dates for which have not yet been announced.

Two Roads Secure Excellent Results from Water Treatment

Reports which have been prepared by the Missouri Pacific and Illinois Central on the operation of their respective systems of water softening for 1920 indicate that water treatment on both of these roads is being attended with highly profitable results. The Missouri Pacific reports a saving for the year of \$481,129 through the use of treated water, a figure representing a return of 197 per cent on the total amount invested in treating facilities, while the Illinois Central reports a saving for the year of \$292,456, or about 120 per cent on the total investment.

Railway Electrical Engineers Will Not Meet

The 1921 annual convention of the Association of Railway Electrical Engineers has been postponed indefinitely. This action was taken by its board of directors as a result of a suggestion made recently by the Association of Railway Executives that the various sections of the American Railway Association postpone indefinitely all conventions or curtail them as much as possible. The Association of Railway Electrical Engineers is not officially connected with the American Railway Association, but has applied for membership.

A Short Lived Strike in Ireland

Enginemen on the Great Northern of Ireland went out on a strike at midnight of August 29, but returned to work the following afternoon on the advice of J. H. Thomas, general secretary of the national Union of Railwaymen, according to the New York Times. Mr. Thomas advised the men to go back to work after the company agreed to participate in the Irish railway arbitration then in progress. The Irish railways were returned to their owners on August 15 at the same time as the British railways were returned, but legislation similar to that provided for the roads of Great Britain has not been extended to the Irish railways.

Some Unit Costs Show Reduction

The Interstate Commerce Commission's monthly bulletin of freight and passenger train service unit costs for the month of June shows a further reduction in some of the unit costs of railroad operation. The cost per freight train mile for selected accounts used by the commission was \$1.753 for the month as compared with \$1.89 last year and the average cost per passenger train mile, selected accounts, was 98.4 cents as compared with \$1.03 last year. For the first six months of 1921, however, the average cost per freight train mile was \$1.95 as compared with \$1.85 last year and per passenger train mile was \$1.07 as compared with \$1.01 last year.

Pennsylvania Pensions

During the first six months of 1921 the Pennsylvania Railroad paid out \$1,354,692 in pension allowances to retired employees; and 696 new names were placed on the pension list in that time. During the same period, 287 retired employees died. The total number now receiving pensions is 6,406. It is estimated that the average term of service of these men is 40 years. The average age of all employees on the roll is 73 years and 1 month.

All officers and employees who attain the age of 70 years are automatically retired, and those from 65 to 69, inclusive, who after thirty or more years in the service become disqualified for active duty, are also eligible for pensions.

Electrification of Japanese Railways

The official plan for the electrification of the railways of Japan has recently been revised and a new electric bureau established, according to information published in Commerce Reports. According to the plan now being worked out by the Department of Railways, the first steps will be to electrify the entire Tokaido line, the traffic of which has been increasing enormously each year, from Tokyo to Kobe, and a part of the Central line between Iidamachi station in Tokyo and Kofu, in the rear of Mount Fuji, where many tunnels make transportation slow. Electric trains will be used exclusively for passengers, freight trains being operated by steam as at present.

Unemployment Conference

The unemployment conference called by President Harding to inquire into the volume and distribution of unemployment and

to consider measures that would tend to recovery of business convened at Washington on September 26. After listening to addresses by the President and by Secretary Hoover of the Department of Commerce, the conference organized by appointing nine sub-committees on various phases of the subject: Unemployment statistics; employment agencies and registration; emergency state and municipal measures and public works; emergency measures by manufacturers; emergency measures in transportation; emergency measures in construction; emergency measures in mining; emergency measures in shipping, and public hearings. Following the appointment of the committees, the conference itself adjourned to October 5, by which time the specialized committees are expected to report.

Reduction in Employees and Their Compensation

A further reduction in the number of employees and the total payroll of the railroads for the second quarter of 1921, as compared with the first quarter, is shown in the Interstate Commerce Commission's quarterly summary of statistics on employees' service and compensation for Class I roads for the three months ending June 30. The average number of employees for the quarter was 1,568,143 as compared with 1,691,471 in the first quarter of 1921. In the third quarter of 1920, when the number of employees was at the maximum, the total was 2,157,989. The number in service at the middle of the month was 1,542,716 for April, but increased to 1,575,599 for May and 1,568,143 for June. The number in service in April was 655,108 less than it was last August.

The total compensation for the second quarter of 1921 was \$699,684,795 as compared with \$757,325,356 in the first quarter of 1921 and \$1,052,109,451 in the third quarter of 1920. The total payroll for the 12 months ending June 30, 1921, was \$3,491,000,000.

C. C. McChord Elected Chairman of I. C. C.

Commissioner Charles Caldwell McChord was unanimously elected chairman of the Interstate Commerce Commission on October 3, succeeding Edgar E. Clark, who recently resigned as a member of the commission to engage in private practice.

Mr. McChord was born December 3, 1859, at Springfield, Ky. He was educated at Center College at Danville, Ky. After leaving college he became a member of the bar of Kentucky and engaged in the general practice of law. He was prosecuting attorney at Springfield from 1886 to 1892. He was appointed a member of the Kentucky Railroad Commission in May, 1892, and elected chairman. He resigned in 1895 and was elected a member of the Kentucky state senate, serving four years. During this time he was the author of the bill which became popularly known as the McChord railroad law, empowering the railroad commission to prescribe freight and passenger rates for railroads in Kentucky. He was again elected a member of the railroad commission in 1899 and was again made chairman. He was re-elected commissioner and chairman in 1903 and in December, 1910, was appointed member of the Interstate Commerce Commission. He was re-appointed by President Wilson for the term expiring at the end of 1922.

District Court Issues Decision in Stoker Suit

The suit brought by the Mechanical Construction Company against the Locomotive Stoker Company for infringement of Patent No. 979,849 to William T. Hanna, was tried before Judge Thomson in the District Court of the United States for the Western District of Pennsylvania in February and March, 1921. The defendant denied infringement, alleged the invalidity of the patent, and by way of counterclaim alleged infringement by the plaintiff of Patent No. 1,130,443. The plaintiff in reply denied the validity of this patent or infringement thereof and asked that the counterclaim be dismissed.

The claim of the Hanna patent covered the use of diverging channels in the distributor plates for the distribution of coal in the firebox. In this suit the decision states, "The claims in suit I find valid and infringed." The counterclaim was based on a fuel receptacle below the firing floor, in regard to which the decision states, "I find that for the reason set forth in this opinion, defendant's counter claim should be dismissed."

The case has been appealed by the Locomotive Stoker Company and it is expected that it will be heard by the upper court early in the October term.

Locomotive Orders

THE CHILEAN STATE RAILWAYS have ordered 10 Mikado type locomotives from the Baldwin Locomotive Works, and 20 Mikado type locomotives from the American Locomotive Company.

Freight Car Orders

THE TIENSIN-PUKOW has ordered from the Pressed Steel Car Company 10 first-class sleeping cars, 10 second-class sleeping cars, and 10 third-class sleeping cars, 5 dining cars, 5 drawing-room cars, 5 baggage, 5 postal and 3 private cars.

THE BANGOR & AROOSTOOK, which has been contemplating the purchase of 200 single sheathed box cars of 40-ton capacity, has ordered this equipment from the Standard Steel Car Company.

Shop Construction

NEW YORK CENTRAL.—This company has awarded a contract for the construction of a 30-stall roundhouse and annex buildings at Solvay, N. Y., to the W. M. Ballard Company, Syracuse, N. Y. Construction was resumed recently on this project.

CHICAGO, ROCK ISLAND & PACIFIC.—This company has awarded a contract to the T. S. Leake Construction Company, Chicago, for the erection of an addition to its roundhouse at Eldon, Mo., to cost about \$40,000.

CHICAGO, BURLINGTON & QUINCY.—This company will construct a 30-ft. by 50-ft. brick machine shop at Herrin Junction, Ill., with company forces.

Bad Order Cars

According to reports compiled by the Car Service Division of the American Railway Association, the number of bad order cars on August 15 totaled 382,440, or 16.6 per cent of the cars on line. The number of bad order cars on September 1, however, showed a slight reduction, the total being 374,087, or 16.2 per cent. Three hundred and seventy-four thousand, four hundred and thirty-one cars were reported in need of repair on September 15, or 16.3 per cent.

Surplus Serviceable Cars

According to reports compiled by the Car Service Division of the American Railway Association, the surplus serviceable cars on August 15 numbered 284,338, a decrease of 13,446 cars when compared with the total for the week ended August 8.

On August 23, the cars totaled 270,024, a decrease of 14,314 cars when compared with the total on August 8.

The total for the week ended August 31 was 246,440, a decrease of 23,584 cars as compared with the preceding week.

For the period September 1 to 8, a total of 237,972 surplus cars was reported, a decrease of 8,468 when compared with the total for the week ended August 31.

The report for the week ended September 15 showed a total of 219,991 surplus freight cars, a decrease of 17,981 cars when compared with the preceding week.

Extending Electric Traction in Italy

The new work for extending electric traction in Italy, which was decided upon before the war by the State Railways in agreement with the government provides for the electrification of about 2,800 miles of the State Railways. The lines chosen are those where the most coal is consumed on account of the steep grades and very heavy traffic. The total length of line operated by the State Railways, is 8,700 miles and the annual consumption of coal is about 2,500,000 tons. The electrification of 2,800 miles, decided upon in the May, 1920, program, will permit of a saving of 1,300,000 tons of coal, or nearly half of the total amount required for running the entire system. In its place, 600,000,000 kw. hr. per annum will be consumed and this means that power stations will have to be provided with a capacity of 150,000 kw.

Most of the electric power will be purchased from private power distribution companies, but in order to speed up the work the State Railways have already commenced to build large hydro-electric installations which will operate in parallel with the power stations of the private companies.

Steel Passenger Cars for the Northern Pacific

Sixty-two passenger cars are being rebuilt by the Pullman Company for the Northern Pacific which will be used on trains

Nos. 1 and 2 running between St. Paul and Seattle. A part of the order has been delivered to the railroad company and when completed will consist of 22 coaches, 12 diners, 11 dynamo baggage cars, 12 baggage cars and five mail and express cars. Three business cars are also being rebuilt in similar manner. All of the equipment used on these trains will then be steel. The cars are similar to the latest design of Pullman cars and are built of wood with steel underframes and ends and $\frac{1}{8}$ -inch steel sheathing. The trucks were reinforced to carry the added weight. The advantages ascribed to this type of construction over the all-steel construction are that they are less noisy, are warmer in winter and cooler in summer and more resilient in case of impact. The head end system of lighting with power supplied by a steam turbine driven generator, located in the baggage car, is used on these trains. New switch panels were added to the cars, but the lighting fixtures were not changed. Storage batteries will be used on each car, excepting coaches and straight baggage cars.

Professor E. C. Schmidt Returns to University of Illinois

Edward Charles Schmidt has been appointed professor of railway engineering at the University of Illinois, and head of that department. Professor Schmidt was associate professor and professor of railway engineering at the University for 11 years up to November, 1917, when he resigned to enter military service as Major of Ordnance. He was graduated from Stevens Institute of Technology in 1895 with the degree of mechanical engineer. He was connected with the Kalbfleisch Chemical Company, New York and Buffalo; with the Edison Electric Illuminating Company of Brooklyn, N. Y., and with the American Stoker Company. He first went to Urbana in 1898 as instructor of machine design. After five years there he went into the employ of the American Hoist & Derrick Company of St. Paul, and in 1904-06 he was engineer of tests with the Kerr Turbine Company.

After a comparatively short time in the Ordnance Corps, Professor Schmidt was requisitioned by the Fuel Administration, and later was transferred to the Railway Administration in charge of the campaign for fuel economy in locomotive service. From August, 1919, until the present time, he has been mechanical engineer for the North American Company.

Constitutionality of Election Laws to Be Tested by C. M. & St. P. Officers

H. E. Byram, president of the Chicago, Milwaukee & St. Paul, Burton Hanson, general counsel, L. K. Silcox, general superintendent of motive power, and George T. Martin, assistant to Mr. Silcox, were placed under arrest on September 26 before Judge F. S. Righeimer of the Cook County Court, Chicago, on warrants charging violation of the election laws by refusing to pay employees for two hours during which they were absent from their work to cast ballots on election days. Mr. Byram and the other officers appeared before the court voluntarily with the object of making this a test case. The officers furnished bonds of \$1,000 each and their case was set for hearing on October 17.

Attorneys representing the four officers of the St. Paul have filed a brief containing 17 reasons why that section of the election law giving employees two hours with pay in which to vote is unconstitutional. Among other points, the attorneys contend that the act is invalid because "it is contrary to the policy of law that any person should be paid for performing that duty of citizenship which consists in attending the polls and voting at elections." Another contention is that the act "seeks to take the property of one citizen for the private use of another citizen."

Federated Shop Crafts Announce Strike Vote

Railroad shop employees, members of the Federated Shop Crafts, have decided by a "constitutional majority," to strike in protest against the recent wage reduction authorized by the Railroad Labor Board, according to the announcement made by B. M. Jewell, president of the Railway Employees' Department of the American Federation of Labor, at a mass meeting of shop employees at Chicago on September 18. Mr. Jewell stated that no strike had been called because the organization leaders believed that their cause will be considerably strengthened if the contemplated strike is called in protest against changes both in the wage scale and in the rules and working conditions.

General charges that the railroads were opposing the demands of the organizations as part of the movement which Mr. Jewell said was backed by "nine billion dollars or more" were made. The object, he said, was "to crush organized labor." In support of this charge he cited the "unfair action of the railroads in offering to negotiate working rules on each road and then failing to agree."

N. P. Good, chairman of the Pennsylvania System Federation No. 90, expressed his opinion that the Pennsylvania had been selected by the railroads to conduct a fight for the "open shop" as the first step in a campaign which would eventually involve all the railroads. Practically all of the speakers at the meeting condemned the Railroad Labor Board and its decisions, Mr. Jewell charging that the railroads were attempting to use the board to take unfair advantage of the present industrial situation.

Freight Car Loading

The total number of revenue freight cars loaded for the week ended August 13, according to reports compiled by the Car Service Division of the American Railway Association, was 808,965, an increase of 24,184 cars when compared with the preceding week. During the corresponding weeks of 1920 and 1919, 162,304 and 23,474 cars, respectively, less were loaded.

During the week ended August 20, 816,436 freight cars were loaded. This was an increase of 7,471 cars over the preceding week, but was a decrease of 151,667 and 96,773 cars when compared with the preceding weeks of 1920 and 1919, respectively.

Eight hundred and twenty-nine thousand, seven hundred and nine cars were loaded during the week ended August 27, an increase of 13,273 cars over the preceding week. During the corresponding week of 1920, 171,599 cars less were loaded.

A total of 830,601 cars was loaded during the week ended September 3, an increase of 892 cars when compared with the total on August 27, and a decrease of 131,032 cars when compared with the corresponding week of 1920.

During the week ended September 10, 748,118 cars were loaded with revenue freight, 82,483 cars less when compared with the total on September 3. This decrease was due to the observance of the Labor Day holiday. One hundred and thirty-five thousand, two hundred and ninety-seven cars less were loaded during the corresponding week of 1920.

The largest number loaded during any one week since the week of December 4, 1920, was reported for the week ended September 17, the total being 853,762 cars. This was an increase of 105,644 cars when compared with the preceding week and a decrease of 137,404 cars when compared with the corresponding week of last year.

Reorganization of Car Service Division, A. R. A.

The Car Service Division of the American Railway Association has been reorganized, and M. J. Gormley has been appointed chairman. The chairmanship will be the point of contact between the Car Service Division and the Interstate Commerce Commission on all details relating to car matters. Mr. Gormley will have general supervision over the activities of the division and will report to the president of the American Railway Association.

Car service managers are W. C. Kendall, A. G. Gutheim, W. J. McGarry, and L. M. Betts. J. J. Pelley is manager of the refrigerator department with headquarters at the Manhattan building, Chicago. C. F. Sewart is manager of the troop movement department and C. A. Buch is secretary. The manager of the refrigerator department will also act as district manager at Chicago. It is proposed to appoint district managers at other important centers if necessary.

The car service managers are assigned as follows: W. C. Kendall to the Railroad Relations Section; A. G. Gutheim to the Public Relations Section; L. M. Betts to the Closed Car Section; and W. J. McGarry to the Open Car Section. The Railroad Relations Section will handle all questions relating to car service and per diem rules, analyze statistics not in the field of other departments, supervise the work of local car service committees, district managers and inspection forces and supervise the placement and cancellation of embargoes. The Public Relations Section will co-operate with government and local authorities other than the Interstate Commerce Commission and make special studies of various classes of traffic from time to time. The sections dealing with closed, open and refrigerator cars will supervise the distri-

bution of the classes of cars assigned to their jurisdiction. The Secretary is responsible for the organization of the division's general office.

Westinghouse Reported to Have Received Large Chilean Contract

The Westinghouse Electric International Company has announced that it has received final confirmation of the contract to supply the equipment for electrifying the Chilean State Railway between Valparaiso and Santiago and to Los Andes, according to the Wall Street Journal.

The contract received from the Chilean government through the company's Chilean agents, Errazuriz, Simpson & Co., associated with Spruille Braden of New York, continues the Wall Street Journal, covers the most important railway electrification since the beginning of the war and the largest ever undertaken by an American firm outside of the United States. The main line, which is 116 miles long and is now under steam operation, is the most important in Chile. It connects the leading seaport, Valparaiso, with the capital, while the line to Los Andes is 28 miles long and forms the Chilean end of the trans-continental route to Buenos Aires.

The contract, which has a total value of \$7,000,000, was secured in spite of keen competition from German and other European concerns. The award was given to the American firm because of its more complete and accurate engineering analysis of the proposition as well as its lower price.

The equipment to be furnished consists of 11 passenger locomotives, 15 road freight locomotives and 7 switching locomotives, together with five sub-stations of 4,000 k. w. each. The 3,000-volt direct current system will be used and all standards will be strictly American in character. Capacity of this equipment will be 50 per cent greater than the present traffic demands, and the plans have been so drawn that an increase of traffic capacity to three times the present amount can be readily obtained. Owing to the abundance of water power in Chile and the high price of fuel, practically all of the Chilean railways will probably eventually be electrified and the present project is the first step in this process.

Other American concerns that will participate in additional awards for the requirements of the Chilean railways, according to the Wall Street Journal, are the American Locomotive Company, the Pressed Steel Car Company and the Anaconda Copper Mining Company.

Contracts for Car Repairs

THE ERIE has entered into a contract with the Youngstown Steel Car Company, Niles, Ohio, for the repair of 400 coal cars, of 50-ton capacity.

THE NEW YORK CENTRAL has given an order for the repair of 250 steel cars to the Cleveland Car Company, Cleveland, Ohio, and for 500 steel cars to the Ryan Car Company, Chicago. This is in addition to the repairs reported in the September issue of the *Railway Mechanical Engineer* for a total of 6,500 cars.

THE ILLINOIS CENTRAL has placed orders for car repairs as follows: 254 ballast cars and 500 box cars with the Pullman Company; 360 gondola cars with the Haskell-Barker Car Company; 500 box cars with the American Car & Foundry Company, and 400 box cars with the Ryan Car Company.

THE PERE MARQUETTE has awarded a contract for the repair of 350 wooden box cars to the International Car Company.

THE SOUTHERN PACIFIC, on account of the return of bad order cars to its lines, in larger numbers than could be expeditiously handled by its own forces, is having repairs made to some of these cars at the shops of the Southern Dry Dock & Shipbuilding Company at Orange, Tex. Up to the present time 100 cars have been repaired at these shops.

THE VIRGINIAN is having repairs made to 100 freight cars at the shops of the Mt. Vernon Car Manufacturing Company.

THE WABASH has given an order to the Western Steel Car & Foundry Company, for making repairs to 200 to 250 all steel hopper cars, of 40-ton capacity.

THE CHICAGO, ROCK ISLAND & PACIFIC is having repairs made to 125 general service gondola cars of 50-ton capacity at the shops of the Western Steel Car & Foundry Company, and has also awarded a contract for the repair of 125 steel gondola cars to the Bettendorf Company, Bettendorf, Ia.

THE PITTSBURGH & LAKE ERIE has awarded a contract for the repair of 1,000 freight cars to the Standard Steel Car Company.

THE CHICAGO, MILWAUKEE & ST. PAUL has awarded a contract for the repair of 300, 50-ton composite gondola cars to the Bettendorf Company, Bettendorf, Iowa, and has also awarded a contract for the repair of 100 composite gondola cars to the Western Steel Car & Foundry Company, Chicago.

Eye Accidents and Faulty Vision Cause Waste in Industries

Eye accidents are revealed as an important source of avoidable national waste in a special report of the Committee on Elimination of Waste in Industry of American Engineering Council, just made public. The report embodies the results of an investigation conducted in many states in connection with the assay of waste in basic industries started by Herbert Hoover.

The total number of industrial blind in the United States is given as 15,000 or 13.5 per cent of the total blind population, this type of injury being the leading causative factor of blindness, according to the report, which was prepared by Earle B. Fowler. The eye, it was found, is involved in 10.6 per cent of all permanently disabling accidents.

Present protective methods as applied in large plants have effected a great reduction in injuries. The use of goggles is one of the chief protective devices. In the plants of the American Car & Foundry Company there has been a reduction of more than 75 per cent through the use of goggles and the percentage of reduction would be much higher if the men would wear goggles more conscientiously, according to the management. Not a single case of injury to the eyes from broken glass has been recorded since goggles were introduced into the shops of the New York Central. All employees of the Union Pacific are now required to wear goggles on eye dangerous work. Striking reductions in eye accidents are also shown by the American Locomotive Company and the American Steel Foundries, eye accidents in the plant of the latter company having been reduced 85 per cent.

The report also states that industrial waste is chargeable to sub-normal vision and faulty lighting. The correction of sub-standard vision produces an increase in return that will pay for its cost in the opinion of the management in plants where several years of trial has provided a basis for judgment. The report states that it has been shown improved lighting systems increase output two per cent in steel plants and as much as 10 per cent in shoe factories where work is more exacting. The cost of providing adequate illumination for the entire industry of the country would amount to one half per cent to one per cent of wages. One estimate placed the loss due to faulty conditions in this country as above the entire cost of illumination. Of the 466 plants investigated, only 8.7 per cent were found to have lighting conditions that could be rated as excellent.

Bids on Equipment for China

Frank Rhea, trade commissioner at Peking, has prepared an interesting analysis of the recent bids of equipment concerns for cars and locomotives for China. The successful bids were not accepted on a basis of price alone, but also on strict adherence to the specifications. The bids were as follows:

30 PRAIRIE TYPE LOCOMOTIVES			
Nationality		Nationality	
Belgian	\$35,610	German	\$49,215*
Japanese	40,296	British	50,878
American	44,200*		
6 BRITISH TYPE LOCOMOTIVES			
Belgian	34,201	British	43,805
American	43,230*	German	49,540*
3 PACIFIC TYPE LOCOMOTIVES			
American	50,880*	British	53,348
Japanese	39,822	German	53,910*
Belgian	40,525		
2 MIKADO TYPE LOCOMOTIVES			
American	52,000*	British	55,567
Belgian	43,170	German	57,000*
Japanese	47,408		
100 OPEN CARS			
Belgian	2,464	Japanese	2,844
German	2,283	British	3,786
American	2,550*		
100 COVERED CARS			
Belgian	2,674	American	2,620*
German	2,509	British	4,325

Note—Shanghai Taels shown as dollars at .645.

*Original bid in dollars.

From the above tables it will be noticed that the Belgian and Japanese bids are usually lowest and the British and German the highest with the American bids intermediate. The successful bidders in each case were as follows:

Orders	Successful bidders	Manufacturers
30 Prairie locomotives..	Société Belge pour l'Export. Ind.	Various Belgian manufacturers.
6 British locomotives..	Société Belge pour l'Export. Ind.	Various Belgian manufacturers.
2 Mikado locomotives..	Mitsui Bussan Kaisha.	American Locomotive Company.
3 Pacific locomotives..	Mitsui Bussan Kaisha	American Locomotive Company.
100 Open cars.....	Fearon, Daniel & Co.	Cie, Général de Construction, Belgium.
100 Covered cars.....	Fearon, Daniel & Co.	Cie, Général de Construction, Belgium.

It will be noted that the greater part of the business went to Belgium, because these bids were in most cases the lowest conforming strictly to specifications. The factor of exchange, of course, enters largely into these bids. According to Mr. Rhea, if the Belgian franc would increase from 8 cents to 10 cents in exchange value the Belgian bids would in most cases cited above have been higher than the American bids.

MEETINGS AND CONVENTIONS

The following list gives names of secretaries, dates of next or regular meetings and places of meeting of mechanical associations and railroad clubs:

- AIR-BRAKE ASSOCIATION.—F. M. Nellis, Room 3014, 165 Broadway, New York City.
- AMERICAN RAILWAY ASSOCIATION, DIVISION V—MECHANICAL.—V. R. Hawthorne, 431 South Dearborn St., Chicago.
- DIVISION V—EQUIPMENT PAINTING DIVISION.—V. R. Hawthorne, Chicago.
- AMERICAN RAILWAY ASSOCIATION, DIVISION VI—PURCHASES AND STORES.—J. P. Murphy, N. Y. C., Collinwood, Ohio.
- AMERICAN RAILROAD MASTER TINNERS' COPPERSMITHS' AND PIPEFITTERS' ASSOCIATION.—C. Borchardt, 202 North Hamlin Ave., Chicago.
- AMERICAN RAILWAY TOOL FOREMEN'S ASSOCIATION.—R. D. Fletcher, 1145 E. Marquette Road, Chicago.
- AMERICAN SOCIETY FOR TESTING MATERIALS.—C. L. Warwick, University of Pennsylvania, Philadelphia, Pa.
- AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Calvin W. Rice, 29 W. Thirty-ninth St., New York.
- AMERICAN SOCIETY FOR STEEL TREATING.—W. H. Eisenman, 4600 Prospect Ave., Cleveland, Ohio.
- ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.—Joseph A. Andreucetti, C. & N. W., Room 411, C. & N. W. Station, Chicago, Ill.
- CANADIAN RAILWAY CLUB.—W. A. Booth, 131 Charron St., Montreal, Que. Next meeting October 11, Windsor Hotel. Paper on Studies on the Corrosion of Iron and Steel will be presented by Dr. Alberton S. Cushman, Institution of Industrial Research, Washington, D. C.
- CAR FOREMEN'S ASSOCIATION OF CHICAGO.—Aaron Kline, 626 N. Pine Ave., Chicago, Ill. Meeting second Monday in month, except June, July and August, New Morrison Hotel, Chicago, Ill.
- CAR FOREMEN'S ASSOCIATION OF ST. LOUIS.—Thomas B. Koeneke, 604 Federal Reserve Bank Building, St. Louis, Mo. Meetings first Tuesday in month at the American Hotel Annex, St. Louis, Mo.
- CENTRAL RAILWAY CLUB.—H. D. Vought, 26 Cortlandt St., New York, N. Y. Annual dinner Thursday evening, November 10, at 7:30 p. m. Hon. Charles F. Moore, the Virginia judge, will be toastmaster. A prominent speaker will be present. Dancing and other entertainments.
- CHIEF INTERCHANGE CAR INSPECTORS' AND CAR FOREMEN'S ASSOCIATION.—W. P. Elliott, T. R. R. A. of St. Louis, East St. Louis, Ill.
- CINCINNATI RAILWAY CLUB.—W. C. Cooder, Union Central Building, Cincinnati, Ohio. Meeting second Tuesday of February, May, September and November, at Hotel Sinton, Cincinnati.
- DIXIE AIR BRAKE CLUB.—E. F. O'Connor, 10 West Grace St., Richmond, Va.
- INTERNATIONAL RAILROAD MASTER BLACKSMITHS' ASSOCIATION.—W. J. Mayer, Michigan Central, 715 Clarke Ave., Detroit, Mich.
- INTERNATIONAL RAILWAY FUEL ASSOCIATION.—J. G. Crawford, 702 East Fifty-first St., Chicago, Ill.
- INTERNATIONAL RAILWAY GENERAL FOREMEN'S ASSOCIATION.—William Hall, 1061 W. Wabasha Ave., Winona, Minn.
- MASTER BOILERMAKERS' ASSOCIATION.—Harry D. Vought, 26 Cortlandt St., New York, N. Y. Next annual convention Hotel Sherman, Chicago, May 23 to 26, 1922.
- NEW ENGLAND RAILROAD CLUB.—W. E. Cade, Jr., 683 Atlantic Ave., Boston, Mass. Next meeting October 11. Paper to be read on Organization Mobilization and Activities of The Canadian Overseas Railway Construction Corps. Addresses by F. L. Wanklyn, chief executive assistant, and Grant Hall, vice-president, Canadian Pacific Railway.
- NEW YORK RAILROAD CLUB.—H. D. Vought, 26 Cortlandt St., New York, N. Y.
- NIAGARA FRONTIER CAR MEN'S ASSOCIATION.—George A. J. Hochgreb, 623 Brisbane Building, Buffalo, N. Y.
- PACIFIC RAILWAY CLUB.—W. S. Wollner, 64 Pine St., San Francisco, Cal. Next meeting October 13. Paper on Locomotive Construction will be presented by Arthur J. Benter of the Baldwin Locomotive Works. Eight reels of motion picture showing locomotive construction.
- RAILWAY CLUB OF PITTSBURGH.—J. D. Conway, 515 Grandview Ave., Pittsburgh, Pa. Next meeting October 27. Annual smoker and entertainment. Election of officers.
- ST. LOUIS RAILWAY CLUB.—B. W. Frauenthal, Union Station, St. Louis, Mo. Meeting second Friday of each month, except June, July and August.
- TRAVELING ENGINEERS' ASSOCIATION.—W. O. Thompson, 1177 East Ninety-eighth St., Cleveland, Ohio.
- WESTERN RAILWAY CLUB.—Bruce V. Crandall, 14 E. Jackson Boulevard, Chicago. Next meeting October 17. Paper on Car Owners' Responsibility will be presented by C. J. Wymer, superintendent car department, Chicago & Eastern Illinois.

PERSONAL MENTION

GENERAL

A. W. KIRKLAND has been appointed acting superintendent of motive power of the Atlanta, Birmingham & Atlantic, with headquarters at Atlanta, Ga., during the absence of J. F. Sheahan.

J. A. CARNEY, superintendent of shops of the Chicago, Burlington & Quincy, at Aurora, Ill., has been appointed supervisor of fuel economy, with headquarters at Chicago. H. Modaff, master mechanic of the Ottumwa division, with headquarters at Ottumwa, Iowa, will succeed Mr. Carney as superintendent of shops at Aurora. H. C. Turner will succeed Mr. Modaff as master mechanic.

MASTER MECHANICS AND ROAD FOREMEN OF ENGINES

B. ADDISON ORLAND, formerly general foreman of the mechanical department of the Mobile & Ohio at Murphysboro, Ill., has been promoted to master mechanic, with the same headquarters, and jurisdiction from East St. Louis, Ill., to Tamms, Ill. Mr. Orland was born on July 7, 1868, at Cleveland, Ohio, and was educated in the public schools. He began his railroad career on August 4, 1884, in the shops of the Cleveland, Columbus, Cincinnati & Indianapolis at Mattoon, Ill., as a machinist apprentice, entering the employ of the Mobile & Ohio on March 15, 1889, as a machinist at Murphysboro. On March 17, 1891, he was promoted to roundhouse foreman; on February 1, 1900, became general foreman, and on February 1, 1902, was transferred temporarily as master mechanic to Whistler, Ala., resuming his duties as general foreman at Murphysboro on January 1, 1903.

G. T. DEPUE has been appointed master mechanic of the Erie at Marion, Ohio, succeeding R. V. Blocker, resigned. Mr. Depue was born on December 2, 1872, in Hornell, N. Y., and received

his education in the grammar schools. On March 1, 1889, he entered the employ of the Erie as a machinist apprentice. After that he worked as a machinist and extra gang foreman until March 1, 1901, when he was promoted to the position of general foreman of the Bradford division, with headquarters at Bradford, Pa. On August 1, 1901, he was appointed general foreman of the Hornell shop; on July 1, 1903, master mechanic at Hornell; on April 1, 1908, master mechanic at Galion, Ohio; on August 1, 1913, shop superintendent at Galion,



G. T. Depue

and on July 1, 1916, shop superintendent at Susquehanna, Pa. On March 1, 1920, when the Erie was reorganized, he was appointed mechanical superintendent of the Chicago region, and on April 1 of this year became shop superintendent at Galion.

SHOP AND ENGINEHOUSE

GEORGE CANFIELD, air brake inspector of the Canadian National at Capreol, Ont., has been appointed locomotive foreman, with headquarters at Jelicoe, Ont. Mr. Canfield was born on May 6, 1893, at Eagle Grove, Iowa, and entered the employ of the Canadian Northern in September, 1904, continuing his public school education at night. He served first as a call boy at Port Arthur, then as a machinist apprentice and machinist until October 14, 1915, when he was subsequently employed as a locomotive foreman at Jelicoe; air brake inspector and assistant foreman at Capreol; locomotive foreman at Brent; machinist at Capreol; locomotive foreman at Foleyet; general foreman at Hornpayne; air brake inspector at Capreol, and on June 12, 1921, was re-appointed locomotive foreman at Jelicoe.

SUPPLY TRADE NOTES

Kearney & Trecker, Milwaukee, Wis., announces the removal of its New York office from the Singer building to the Hudson Terminal building, 50 Church street.

J. E. Slimp, formerly with the Ohio Brass Company, and recently with the E. T. Chapin Company, Spokane, Wash., as sales manager with office at Chicago, has resigned.

H. S. Durant has been appointed sales agent, and M. W. Floto assistant sales agent, at the Detroit office of the American Steel & Wire Company, Chicago, to succeed M. Whaling and T. J. Usher, Jr., resigned.

William S. Murray, formerly chairman of the Superpower Survey, and Henry Flood, Jr., formerly engineer secretary of the Superpower Survey, have formed the firm of Murray & Flood, Grand Central Terminal, New York.

Theodore Rogatchoff has been elected president of the Rogatchoff Company, Baltimore, Md., succeeding A. E. Davis. The company has moved its offices in Baltimore from 205 Water street to 1512 Latrobe terrace.

William C. Wolfe has been appointed manager of sales of the Highland Iron & Steel Company, Terre Haute, Ind., a subsidiary of the American Chain Company. Mr. Wolfe's headquarters will be at 208 South La Salle street, Chicago.

R. H. Blackall has been appointed railway sales representative for the New York territory of The Lowe Brothers Company, Dayton, Ohio, with offices at 7 East Forty-second street, New York City and Farmers Bank building, Pittsburgh, Pa.

Thomas Madill, who served for many years in the sales department of the Sherwin-Williams Company, Cleveland, O., died in Los Angeles, Cal., on July 23. He spent practically his entire business life with The Sherwin-Williams Company in its railway trade.

Thomas H. Greenwood has been appointed factory manager of the McDougall-Butler Co., Inc., Buffalo, N. Y., makers of paint and varnish for railway uses. This company has appointed the Ehrlich Paint Company, Cincinnati, Ohio, as its representative in the Cincinnati district.

The Stowell Company, South Milwaukee, Wis., has effected a merger with the Pelton Steel Company, Milwaukee. The Pelton Steel Company name will be retained and the plant will continue to be operated by the same organization, under the direction of the officers and directors of the Stowell Company.

G. H. Redding has been elected secretary of the Massey Concrete Products Corporation, succeeding F. C. Shannon, formerly vice-president and secretary, and the position of vice-president will remain unfilled for the time being. David A. Hultgren has been appointed resident manager at Chicago, for the company.

J. H. McMullen has been appointed railroad representative in the Boston, Mass., territory, for the Western Electric Company, succeeding E. R. Morgan, and E. B. Denison, formerly in charge of the Minneapolis, Minn., territory, has been appointed Detroit, Mich., railroad representative, succeeding R. S. Cowan.

The English Electric Company of Canada, Ltd., a newly-formed company associated with the English Electric Company of Great Britain, has acquired control of the Canadian Crocker-Wheeler Company, Ltd. R. A. Stinson, vice-president and general manager of the latter company, has been elected president and general manager of the new company.

The Metals Coating Company of America, manufacturers and distributors of the Schoop Metal Spraying Process by means of which metallic coatings of any kind may be sprayed onto any surface, is now in full operation at its new plant, 495-497 North Third street, Philadelphia, Pa., having re-

moved from their former Boston, Mass., and Woonsocket, R. I., locations.

A. H. Handlan, Jr., vice-president and manager of the Handlan-Buck Manufacturing Company, St. Louis, Mo., has been elected president of the company, succeeding his father, the late A. H. Handlan; E. W. Handlan, vice-president and treasurer, has been made vice-president; E. R. Handlan, secretary, has also been elected to a vice-presidency, and R. D. Teasdale has been appointed secretary.

Robert D. Black has been appointed manager of the Philadelphia branch office of the Black & Decker Manufacturing Company with headquarters at 318 North Broad street. He succeeds W. C. Allen who has been appointed special factory representative, with headquarters at the Cleveland branch office, 6225 Carnegie avenue. Mr. Black was formerly assistant sales manager of the company.

Fred A. Poor, Patrick H. Joyce, and Edward N. Roth, have been elected members of the board of directors of Mudge & Co., Chicago. There has been no change in the control of the company, its management being as heretofore in charge of Burton Mudge, president, and Robert Sinclair, vice-president. The other directors of the company are Burton Mudge, Robert Sinclair, Egbert H. Gold and Edwin W. Sims.

John C. Robinson has resigned as manager of New England sales at Boston, Mass., for William Wharton, Jr., & Co., Inc., Easton, Pa., after 30 years of continuous service. Mr. Robinson will in future devote his time to his interests in the firm of Harrington, Robinson & Co., Boston. The Boston office of the Taylor-Wharton Iron & Steel Company, High Bridge, N. J., and William Wharton, Jr., & Co., Inc., is now at 201 Devonshire street, in charge of Walter H. Allen.

Edward B. Germain, general manager of the Harlan plant, Bethlehem Shipbuilding Corporation, Wilmington, Del., has been appointed manager of sales of the corporation, with office at 111 Broadway, New York. Mr. Germain went to Wilmington in December, 1918, from Elizabeth, N. J., where he held the position of general manager of the Moore plant of the same corporation. Cecil W. Weaver, formerly general superintendent of the marine department, succeeds Mr. Germain. The Harlan plant, besides its shipbuilding and ship repair facilities, has extensive passenger shops with a capacity of 250 steel passenger coaches a year.

Horace C. Hides, who for the past 20 years represented Wm. Jessop & Sons, Sheffield, England, has been appointed general sales manager in the United States for Thos. Firth & Sons, Ltd., Sheffield. This firm recently terminated its agency arrangement for the sale of sheet steel with Wheelock Lovejoy & Co., of New York and Cambridge. Mr. Hides will have his headquarters in Hartford, Conn., where a joint office has been opened by Thomas Firth & Sons, Ltd., and an associate company, the Firth-Sterling Steel Company, New York; Henry I. Moore will represent the latter company at Hartford.

The Pennsylvania Car Company has been incorporated under the laws of Delaware, with a capital of \$1,000,000 to engage in the building of railroad cars. The incorporators are: J. H. Van Moss, James H. Durbin, L. B. Coppinger, and the Corporation Trust Company of Delaware. Plants equipped with latest improved machinery will be constructed at Sharon, Pa., at Argentine station, Kansas City, Kan., and at Houston, Texas. This company is affiliated with the interests that control the Pennsylvania Tank Car Company and the Pennsylvania Tank Line, Sharon, Pa., and the present plans call for the development of one of the largest organizations of its kind in the country.

The Conewango Car Company, incorporated in Delaware, has leased the site at Warren, Pa., formerly occupied by the Allegheny Tank Car Company, which plant was partly destroyed by fire on April 6 last. The new company will specialize in repairs to tank cars. In addition to three buildings on the site which were not destroyed by fire, the new company has built a car shop, a machine shop and a sand-blast shop, all of which are being equipped with modern machinery. Shop and yard space is provided for repairing

20 cars at a time, as is storage space for 50 additional cars. N. C. Stiteler is president and treasurer of the new company and J. C. Sullivan is vice-president and general manager.

Charles Haines Williams, first vice-president of the Chicago Railway Equipment Company, died at Chicago on the morning of August 8. Mr. Williams was born in Baltimore, Md., on April 1, 1875, and was educated in the public schools of Baltimore and at the Baltimore Polytechnic Institute, from which institution he graduated in 1893. He later took a special course in mechanical drawing and machine design in the Maryland Institute. After four years as a special apprentice in the Mount Clare shops of the Baltimore & Ohio, where he worked in the machine and locomotive shops, the erecting shop and in the foundry, drafting room and test department, Mr. Williams, on July 6, 1897, left the Baltimore & Ohio to become connected with the Chicago Railway Equipment Company, as mechanical inspector. In 1917, he was elected first vice-president of the company and a director, which positions he occupied at the time of his death.

Edward A. Craig, manager of the export department of the Westinghouse Air Brake Company, Pittsburgh, Pa., died on August 28, at his home in Edgewood, Pa. Mr. Craig was born in January, 1873, at Allegheny City, Pa., and was educated in the public schools of that city. He began work in 1888 with the Westinghouse Air Brake Company as a messenger. He subsequently served as secretary to the general superintendent of the works. He later was appointed assistant auditor and then served as auditor and assistant secretary. In 1906, the company established the Southeastern district, with Mr. Craig as manager. He remained in that position until the export department was organized in January, 1920, and since that time he served as manager of the export department.

Kenneth Rushton, vice-president in charge of engineering of the Baldwin Locomotive Works, died on September 2 at his home at Wynnewood, Pa. Mr. Rushton was born 60 years ago in Philadelphia, Pa., and was educated in the city schools and Episcopal Academy. He served an apprenticeship, as machinist, under Hugo Bilgram, Philadelphia, and afterward entered the employ of the Baldwin Locomotive Works in April, 1881. Mr. Rushton's association with the Baldwin Locomotive Works continued uninterrupted until the time of his death. He served first as a draftsman, and then as designer, chief mechanical engineer and later as vice-president. He was the inventor of many appliances used in the construction of locomotives, and was closely associated with S. M. Vaucrain in the development of the four-cylinder compound that bears

the name of the latter. While Mr. Rushton did not travel extensively in the prosecution of his business, he represented Baldwin's abroad in some important missions. In 1913 he was sent to Chile, visiting various points of railroad interest on the west coast of South America, and in 1918 went to France, in connection with the design of railway transport for artillery.

Carl F. Dietz, vice-president and general sales manager of the Norton Company, Worcester, Mass., has resigned to become president and general manager of the Bridgeport Brass Company, Bridgeport, Conn., succeeding Fred J. Kingsbury, of New Haven, who has been made chairman of the board of directors. Mr. Dietz was connected with the Norton Company for 10 years, first as plants engineer, then as assistant sales manager, and afterward as sales manager of the wheel division of the business. Two years ago, when the Norton Company and the Norton Grinding Company were consolidated, he was made vice-president and general sales manager.

He was born in New York, February 12, 1880, and was graduated from Stevens Institute of Technology in 1901. Subsequently he took post graduate work in engineering studies abroad. Early in his career he was active at plants of the United States Steel Corporation in blast furnace operation. In 1905 he engaged in the development of zinc-smelting processes. The following years were spent in consulting metallurgical and mining work, examinations, design and operation of milling plants in North and South America and various European countries. Mr. Dietz is a member of the American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, the Worcester Club, Engineers' Club of New York, Quinsigamond Lodge of Masons, Chamber of Commerce, Economic Club, Theta Nu Epsilon, Phi Sigma Kappa and University Club of Worcester.

W. La Coste Neilson, vice-president of the Norton Company, has been appointed general sales manager, succeeding Mr. Dietz. Mr. Neilson was born on May 2, 1879, at Philadelphia, Pa., and graduated from Haverford College in 1901. From 1901 to 1905 he was employed by the Standard Steel Works at Burnham, Pa., and was superintendent of the Chester Steel Castings Company from 1906 to 1907, when he entered the employ of the Norton Company. Mr. Neilson served for a few years as assistant sales manager of the Norton Company, then was in charge of all foreign business, including sales and the management of the foreign plants at Wesseling, Germany, and at La Courneuve, France, with office in London, England. He was made a vice-president two years ago.



E. A. Craig



K. Rushton



Carl F. Dietz



W. La Coste Neilson